

NAVAL POSTGRADUATE SCHOOL Monterey, California



CONTRACTING PROCESS INNOVATION

by

Mark E. Nissen

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NAVAL POSTGRADUATE SCHOOL
Monterey, California 93943-5000

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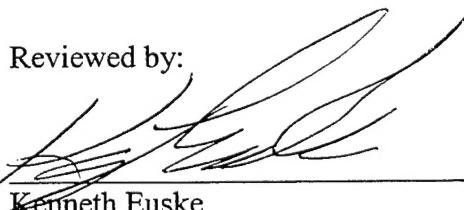
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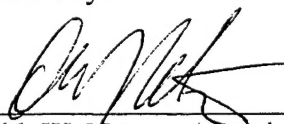
Mark E. Nissen
Assistant Professor
Graduate School of Business and
Public Policy

Reviewed by:



Kenneth Euske
Dean
Graduate School of Business and
Public Policy

Released by:



David W. Netzer, Associate Provost and
Dean of Research

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Abstract

Process innovation pertains to making dramatic improvements in performance of enterprise processes. Stemming from total quality management, business process reengineering and other widely-accepted approaches to performance improvement in the business enterprise, process innovation has largely been practiced without a systematic method and required expertise only possessed by a few, highly-talented people. Now, as the result of research in this area, the *process* of process innovation now has a systematic method that helps ensure consistent and thorough analysis, and through measurement-driven reasoning, an automated tool now exists to enable the relative amateur to innovate enterprise processes as well as the professional. Moreover, process innovation is no longer the exclusive domain of *business* enterprises, as military, governmental and other organizational processes can be innovated with equivalent efficacy using the method and tool described in this book. In particular, the contracting process lends itself to process innovation and is addressed explicitly in this book.

Foreword

Acquisition is increasingly important in the Government and private industry alike. Past and present Defense Secretaries have challenged the acquisition workforce to effect a 50% reduction in the cycle time required to develop and field major weapons systems and acknowledged that acquisition (especially procurement and logistics) now limits battlefield information, mobility and speed. As we enter the new millennium, the "tooth vs. tail" argument no longer holds; that is, even military "tail" processes such as procurement and contracting have become critical success factors for the "teeth" (e.g., warfighting units). However, contracting and other acquisition processes are in dire need of innovation. This book addresses radical change for acquisition through process innovation, with particular emphasis on the contracting process, and it examines in detail one high-leverage approach to innovating the contracting process: alpha contracting.

The "traditional" contracting process is very common and quite flawed. It generally begins with preparation of a statement of work and proceeds through contract negotiation to award. A key point pertaining to this "traditional" or baseline process is, nearly all activities are performed *either* by the Government or contractor, but not both. In contrast, the alpha contracting process involves many activities performed *jointly* by the Government and contractor teams. This process innovation offers a number of advantages and performance enhancements, such as improving communications, decreasing the number of *formal* RFP iterations, revisions and rework required to correct misunderstandings, errors and mistakes, reducing the cycle time (procurement administrative lead time or PALT) required for contracting and others. But performance improvement does not have to stop with alpha contracting. The central premise of this book is that an already-innovative process such as alpha contracting can be further innovated through systematic process redesign, which involves reengineering and managing radical change.

Nearly all large U.S. corporations have engaged in major reengineering projects, and the Government, including many military commands, is also deeply involved in reengineering today. Business process reengineering (BPR) builds on good principles set forth through Total Quality Management (TQM), but it differs fundamentally. For instance, whereas TQM stresses continuous, incremental process improvements, the emphasis of BPR is on dramatic, order-of-magnitude leaps in process performance, achieved through radical process redesign. The primary reason most firms reengineer is either to keep up with performance improvements effected at rival firms to attain competitive advantages of their own. But the military and government also have a great need for BPR-level performance and efficiency gains to offset the effects of downsizing.

Using a systematic, measurement-driven approach to process redesign, this book explains in considerable detail how process innovation can be effected for a variety of processes, and it specifically targets the contracting process for such innovation. The discussion draws from experience with very successful alpha contracting processes (e.g., as practiced on the Joint Standoff Weapon (JSOW) system) to demonstrate both application of measurement-driven process redesign and illustrate how further innovation is possible. After providing the necessary background information in the first three

chapters—discussing acquisition criticality, alpha contracting and process innovation—the JSOW alpha contracting process is modeled for redesign analysis, measured to diagnose pathologies and redesigned to further improve performance. Measurements reveal a number of serious pathologies with the alpha contracting process, which have adverse implications in terms of both cost and cycle time. Based on these diagnosed pathologies, several classes of redesigns are examined. Both individually and in combination, these process redesigns offer good potential for dramatic performance improvement, in terms of reduced cost *and* cycle time. We also examine the use of advanced information technology to construct a vision of the future of procurement. Such a vision is important to guide research and represents a goal toward which contract managers should strive.

This book is written for a relatively broad audience of acquisition executives, policy makers, practitioners, educators and researchers. Although it draws heavily from current research—for example describing state-of-the-art tools, techniques and technologies—it does not require a Ph.D. to read, understand and learn to act on the material. Any acquisition manager with a vision, or who does not feel the current acquisition system (even as reformed) is as efficient and effective as it can be, should be able to appreciate this book and apply its concepts and methods in the workplace. This is the central objective of the book.

M.E.N. October 1999, Monterey, California.

About the Author

Mark E. Nissen is Assistant Professor of Information Systems and Acquisition Management at the Naval Postgraduate School and Office of Naval Research Young Investigator. His research focuses on the investigation of knowledge systems for enabling and managing change in areas such as process innovation, electronic business and knowledge flow. Recently he has been investigating knowledge systems to innovate processes in the acquisition domain, and he is currently involved with intelligent supply chain agents, as well as techniques and technologies for the capture and distribution of knowledge in very-large enterprises. Mark's publications span both the information systems and acquisition fields, with recent and forthcoming articles in journals such as *MIS Quarterly*, *Journal of Management Information Systems*, *Decision Support Systems*, *Journal of Information Technology Management*, *Acquisition Review Quarterly* and *National Contract Management Journal*. He has also recently published his first book, entitled *Contracting Process Innovation*, and he received the Menneken Faculty Award for Excellence in Scientific Research, the top research honor bestowed upon faculty at the Naval Postgraduate School. Before his information systems doctoral work at the University of Southern California, he acquired over a dozen years' management experience in the aerospace and electronics industry and served as a Supply Officer in the Naval Reserve.

Learning objectives

The book also addresses five learning objectives. Through this book, the reader should be able to:

- Understand and appreciate the importance of acquisition as a strategic activity.
- Understand the fundamental differences between traditional and alpha contracting, and understand alpha contracting's strengths and limitations.
- Differentiate radical process change from incremental improvement. Reengineering techniques build upon those of TQM, yet they differ in many respects.
- Redesign contracting processes for dramatic performance gains. Methods and technologies discussed in this book are applied directly to contracting processes to ensure grounded, practical understanding.
- Follow the references to pursue deeper research and understanding in the above topics. A rich set of references can guide the reader's exploration into the background, subtleties and complementary applications of the lessons presented in this book.

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Chapter 1 - Acquisition Criticality

Material presented in this introductory chapter draws from an *Acquisition Review Quarterly* Special Issue on Managing Radical Change (Nissen, Snider and Lamm 1998). Acquisition represents a critical process to the Department of Defense (DoD). In its current usage, the term *acquisition* pertains to the strategy, planning, procurement, contracting, financing, program management and logistics required to develop, produce and support weapon systems and other materiel required to accomplish the defense mission. The breadth of this term indicates the acquisition process does not apply solely to the DoD; rather, most enterprises in the public and private sectors engage in acquisition. One can argue that the acquisition process is critical for the survival of commercial and defense enterprises alike.

We say that acquisition represents a critical process because it satisfies requirements that are essential to survival; that is, without effective acquisition, neither military, commercial, government nor any other major enterprise can function effectively. Indeed, in the article above, Nissen et al. draw an analogy with the human body, comparing acquisition to such vital bodily functions as eating, drinking and breathing. Such functions are clearly critical for survival, and every athlete understands effective food, drink and air "acquisition" is paramount for athletic performance (e.g., running, cycling, strength).

Despite this critical role, however, the acquisition process suffers from neglect. In the DoD as well as industry, acquisition has long been relegated to the "end of the line" with respect to executive attention, funding, innovation, training, career development and other key enterprise attributes. In the DoD for example, we have long heard funding and prioritization arguments based on the "tooth vs. tail" metaphor; that is, if an organization is financially constrained and unable to procure sufficient assets to support all of its needs and desires, then priority should be given to weapons and battle assets (i.e., the teeth) over administration, support and even logistics. This appears to be very rational, for it has undoubtedly been said that one cannot fight wars with contract administrators and word processors.

Until recently, Corporate America long relied on this same argument. Although not charged with fighting wars, few corporations would hesitate to shift discretionary spending from Quality Assurance to Manufacturing, from Customer Service to Marketing, from Purchasing to Research and Development (R&D) and like prioritizations. However, in the Eighties industry discovered that quality represents a critical performance factor, that customers are increasingly demanding quality products, and even more importantly, that emphasizing quality could actually *save* cost and reduce cycle time. This represents one of the key messages from Total Quality Management.

Likewise, firms discovered that people—both outside the organization and within—increasingly demand courteous and responsive customer service, and that the most brilliant marketing campaign in the world is ineffective at winning-back a customer lost to poor service. And whereas R&D represents the

fundamental mechanism for new product and service development for the Hierarchy (cf. Williamson 1985 for comparison of markets and hierarchies), the time from basic research to new product introduction can be very long. This limits a firm's agility, flexibility and responsiveness to unforeseen changes in the environment and competitive arena (Porter 1985); so many progressive firms are forming strategic networks with other organizations.

Widespread supply-chain integration, just-in-time inventory practices, virtual organizations, mass customization and other contemporary business approaches have required a radical change in the acquisition process of leading firms. For example, the procurement focus has shifted away from arms-length transactions and more toward trust-based relationships. Although price is still vitally important (as always), it is no longer necessarily more so than capability, quality, reliability and trustworthiness. In many cases, the relationship established with a particular vendor, customer, distribution channel or even a competitor makes the difference between being first to market with an innovation and missing the product cycle completely—perhaps while haggling over five percent of the current transaction's purchase price. In today's era of downsizing, global operations and exploding information, progressive companies have realized the environment has shifted abruptly and effected radical change where appropriate.

Recently, we find that acquisition has been achieving an increasing level of importance in the DoD as well. A new emphasis on commercial off-the-shelf (COTS) equipment and software, for example, and a renewed commercial emphasis, higher simplified acquisition threshold and preference for commercial specifications and standards exemplify this importance. The DoD acquisition guidelines even establish as a goal to conduct "business more like business" (DoD Instruction 5000 1996). We also note increasing defense partnerships with industry, less reliance on a shrinking defense-unique industrial base, process reengineering, electronic commerce and other advanced initiatives occurring in the DoD, with much the same intensity that we observed in industry a few years ago. Indeed, realizing the importance of acquisition, the former Secretary of Defense challenged the Acquisition Workforce to effect a 50% reduction in the cycle time required to develop and field major weapons systems (Perry 1994). This represents a call for radical change of reengineering proportions.

In 1997, the Secretary of Defense acknowledged that the acquisition process limited battlefield information, mobility and speed, and he promulgated numerous initiatives (e.g., the Defense Reform Initiative, Cohen 1997) to improve acquisition processes. Referring back to our metaphor from above, the "tooth vs. tail" argument no longer holds. Notwithstanding our breathtaking military performance in the Gulf War, for example, armored units were restrained by the logistical chain. Our ability to strike with overwhelming force required patience and persistence as we amassed troops, supplies and battlefield assets in nearby countries. Even our theater information systems were critically dependent on relationships with commercial vendors for equipment, software and bandwidth in the region.

Metaphorically, regardless of the number and size of one's teeth, you can only run as fast as your tail can follow. And with slow, bureaucratic, cumbersome, inflexible and unresponsive procurement and

logistics processes, battlefield speed is severely constrained after the first few days of intensive conflict. Indeed, with the Defense Reform Initiative, we find that the acquisition process is now on verge of becoming strategic to the military. Acquisition? Strategic? This represents a radical concept for the DoD. A concept that calls for concomitant radical change.

In this book, we address radical change for the DoD through process innovation, with particular emphasis on the contracting process, and examine in detail one high-leverage approach to innovating the contracting process: alpha contracting. Specifically, in the following chapter, we discuss alpha contracting with direct comparisons and contrasts to what we call the "traditional" contracting process. We outline a number of important advantages and disadvantages associated with alpha contracting, and through example, we introduce an alpha contracting decision model that can be used by contract managers to assess the potential risks and benefits of alpha contracting. In the subsequent chapter, we provide an overview of reengineering and process innovation, making specific note of similarities and differences between process innovation and improvement. We then explain useful analytical frameworks, tools and techniques employed for process innovation and show, again through examples, how such approaches can be used to innovate the contracting process. The final chapter integrates the preceding discussion to show how even the alpha contracting process can be further enhanced through process innovation. Each chapter includes a summary and some questions and answers to ensure comprehension of key points. The book concludes with a set of references to support the reader's continued learning along these lines.

CHAPTER 1 SUMMARY

In its current usage, the term *acquisition* pertains to the strategy, planning, procurement, contracting, financing, program management and logistics required to develop, produce and support weapon systems and other materiel required to accomplish the defense mission. The breadth of this term indicates the acquisition process does not apply solely to the DoD. Rather, most enterprises in the public and private sectors engage in acquisition, and one can argue that the acquisition process is critical for the survival of commercial and defense enterprises alike.

Widespread supply-chain integration, just-in-time inventory practices, virtual organizations, mass customization and other contemporary business approaches have required a radical change in the acquisition processes of leading firms. Recently we find that acquisition has been achieving an increasing level of importance in the DoD as well. Past and present Defense Secretaries have challenged the Acquisition Workforce to effect a 50% reduction in the cycle time required to develop and field major weapons systems and acknowledged that acquisition (especially procurement and logistics) now limit battlefield information, mobility and speed. Referring back to our metaphor from above, the "tooth vs. tail" argument no longer holds. This book addresses radical change for the DoD through process innovation,

with particular emphasis on the contracting process, and examines in detail one high-leverage approach to innovating the contracting process: alpha contracting.

CHAPTER 1 QUESTIONS

1. What functional activities are generally included under the term *acquisition*?
2. What contemporary business approaches have required a radical change in the acquisition process of leading firms?
3. What kinds of battlefield and fleet activities can be constrained by a poorly performing acquisition process?

CHAPTER 1 ANSWERS

1. Strategy, planning, procurement, contracting, financing, program management and logistics.
2. Widespread supply-chain integration, just-in-time inventory practices, virtual organizations, mass customization and others.
3. Battlefield information, mobility and speed.

Chapter 2 - Alpha Contracting

This chapter is written to describe alpha contracting as an innovative acquisition reform technique that has now been successfully employed for procurement of numerous products and services. We first provide a general description of the baseline (i.e., "traditional") contracting process that is still practiced in many acquisitions. This is followed by a high-level overview of the alpha contracting process. To support comparative analysis, we summarize alpha contracting experience on a pioneering weapon system program: the Joint Standoff Weapon (JSOW) system. The chapter then builds upon these process descriptions and JSOW experience to formulate a decision model to be used for assessing the likelihood of alpha contracting success.

BASELINE CONTRACTING PROCESS

As noted above, the baseline (i.e., "traditional") contracting process is described here to enhance both comparison and contrast with alpha contracting. This approach is consistent with the specification of an "as is" (i.e., baseline) process model in most business process reengineering (BPR) projects or other engagements involving radical change. And as we shall see, the transition to alpha contracting represents a radical change indeed. Alpha contracting is now broadly employed to procure both products and services, but its application is focused primarily on relatively small, straightforward acquisitions (see Schutter 1998). However, the techniques are in no way limited to such acquisitions, as the JSOW example (an ACAT ID program) shows.

Further, the focus of this section is initially on contracting by negotiation (e.g., as described in FAR Part 15), as applicable to procurement of most major systems. The scale, scope and complexity of such major system acquisitions present a number of challenges in terms of management and integration that can leverage the payoff from effective alpha contracting on ACAT I programs. Thus, their examination reveals many insights into alpha contracting strengths and limitations that do not manifest themselves through smaller, simpler procurements.

The principal elements comprising the baseline contracting process flow¹ are delineated in Figure 1. The activities performed by the buyer (e.g., Government Program Office) are listed as linked activities under the "Government" column heading and those performed by the seller (e.g., commercial contractor) are listed in like fashion under the "Contractor" heading. Those activities performed jointly are listed in the center column to indicate their cooperative/collaborative nature. This process notation combines aspects of the DoD standard Integrated Definition (IDEF) with the "swimlanes" (marked by dotted vertical lines) that have emerged as a common modeling practice in process redesign². Our general process baseline represents

a composite view synthesized from several sources³ and years of experience.

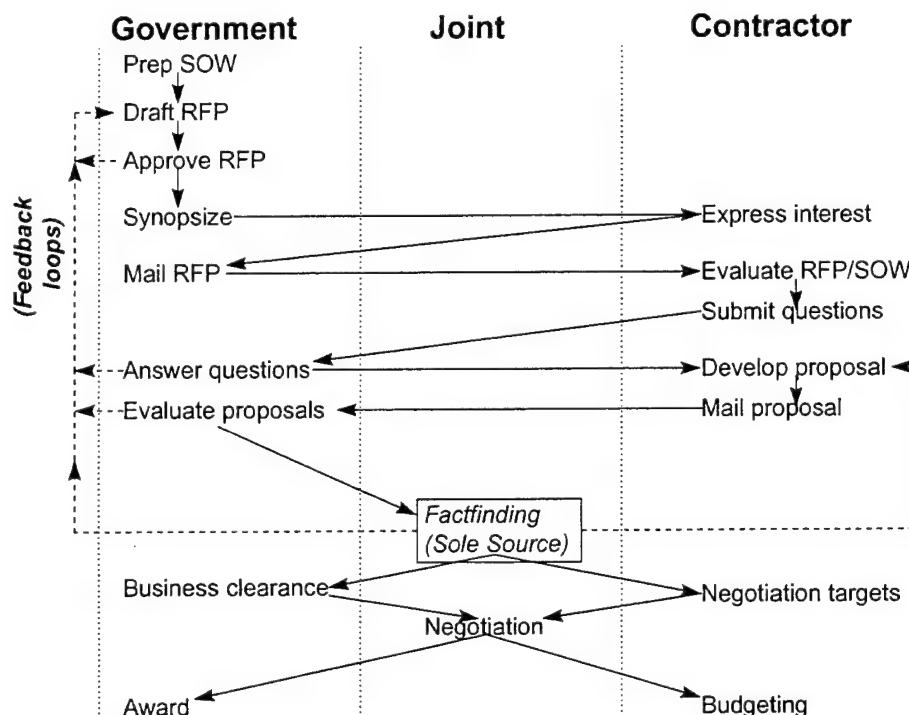


Figure 1 Baseline Contracting Process Flow

Because this baseline contracting process is very common, we outline its key steps only briefly here. For purpose of comparison and contrast between this baseline process and its alpha counterpart, we choose to begin the process description with the preparation of a statement of work (SOW) for prospective solicitation and contract (labeled “Prep SOW” in the figure). Clearly, many important activities take place prior to SOW development (e.g., the Government often solicits industry input through its request-for-information (RFI) instrument). But most of such activities do not accentuate differences between traditional and alpha contracting, so we omit them from the diagram⁴. In the next step (labeled “Draft RFP” in the figure), the other major RFP sections are composed, generally by the technical team and one or more contract specialists. With an approved RFP, a synopsis is followed by a series of iterative steps leading to proposal submittal, fact-finding and eventually contract negotiation.

Notice the multiple feedback loops depicted at various points along the process flow. Experience indicates that few SOWs, RFPs, proposals or contracts are successfully developed without undergoing several iterations and revisions. This is particularly true for major weapon systems in today's dynamic and uncertain budgetary environment. Clearly each “trip” back through such a feedback loop consumes precious acquisition time and money. Notice also—in the baseline process flow—that the fact-finding step represents the first activity in which the Government and contractor personnel work *jointly* toward the end product: a

definitized contract for award. Although many contracting activities continue well beyond this point, for our purpose of comparison and contrast with the alpha contracting process, this process model and description provide the necessary grist for understanding and communicating the key process activities and sequencing.

ALPHA CONTRACTING PROCESS

Using the same process notation, the principal alpha contracting process elements are delineated in Figure 2. Notice, at first glance, how the overall pattern of the process flow differs considerably from that pertaining to the baseline contracting process presented above (esp. in terms of process length, simplicity and collaboration). Also take note that this latter, alpha version of the process accomplishes all of the same results required by its baseline counterpart above. Like the baseline, this general alpha process model represents a composite view synthesized from several sources⁵ and experience.

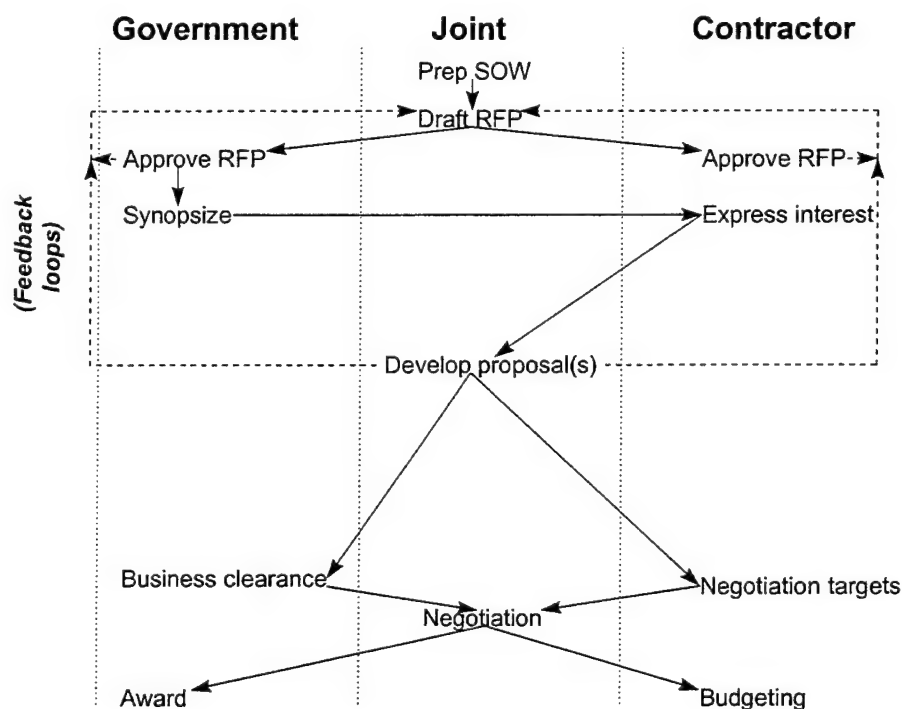


Figure 2 Alpha Contracting Process Flow

Briefly, as with the baseline contracting process, we choose to also begin the alpha contracting process with SOW preparation, which precedes the composition of a draft RFP. In many instances of alpha contracting, the SOW step is replaced by a statement of objectives (SOO), which prescribes only high-level goals for a system, as opposed to the work to be done. However, a SOW must still be developed by someone (e.g., either the Government or contractor). And the underlying steps are essentially the same

regardless of whether performed by the buyer or seller. Hence this SOO approach effectively transfers the SOW-development task from the Government to the contractor or defers its creation until some point after contract award.

The alpha contracting process delineated in Figure 2 strikes a balance between Government-only and contractor-only SOW development. Notice the placement of these activities in the center column of Figure 2 to indicate the activities are performed *jointly* by the government and contractor teams. Once an acquisition strategy and plan (often including a preliminary RFP) have been developed by the Government⁶, technical personnel from *both* the government PMO and contractor organization work together to develop the draft SOW, as do contracts and pricing/estimating personnel to develop the draft RFP. Instead of iteratively trying to accomplish these tasks "at arms length"—and mailing formal documents back and forth—as above in the process baseline, the integrated product team (IPT) approach is employed to jointly develop these key documents.

This approach can be described in terms of an investment. Both teams invest the time and attention of key personnel up-front to jointly develop these contracting documents. The investment has objectives that include: 1) improving communications; 2) decreasing the number of *formal* RFP iterations, revisions and rework required to correct misunderstandings, errors and mistakes; 3) reducing the cycle time (procurement administrative lead time or PALT) required for contracting; 4) increasing the level of trust, openness and mutual respect between the government and contractor teams; and 5) decreasing the overall cost—both for the Government and contractor—associated with the procurement.

Continuing the IPT theme, notice that the "develop proposal(s)" activity is also accomplished jointly; that is, the same people—both government and contractor—who collaborate to develop the SOW and RFP together will continue their collaboration to transform this SOW/RFP document—through a contractor proposal—and make it the contract. Feedback to *both* the government and contractor activities accompanies this key process step. As above, the process proceeds through the business clearance/negotiation targets steps, but notice the separate fact-finding activity is absent from the alpha contracting process model. The point is, the collaborative nature of the preceding process activities (esp. SOW/RFP preparation and proposal development) obviates the need to conduct formal fact-finding as a separate, sequential activity. In the alpha contracting process, this "step" takes place concurrently with the development of the RFP and proposal. This concurrency contributes considerably to the shorter process length that is observable by comparing the two figures.

After the negotiation clearances are obtained, the formal negotiation would proceed as before—in theory—with the two sides achieving a meeting of the minds on the contractual scope, price and language for the acquisition. The key difference is that, at some point, the "collaborative" nature of the activities represented above has the potential to breakdown. Negotiation represents a stressful activity that often reduces to a zero-sum game. Hence collaboration may give way to confrontation, even *before* the formal negotiation step has been reached. We will return to this point. But we note here that such confrontation has

the potential to negate many of the key, trust-based advantages of the alpha contracting process, particularly as the same individuals are expected to jointly collaborate again on the next fiscal year's procurement.

ALPHA CONTRACTING ADVANTAGES AND DISADVANTAGES

Nearly any process change is expected to offer both advantages and disadvantages. A common saying in the software domain, for example, is that there is no "silver bullet" (e.g., see Brooks 1987). This means that no single change or innovation is sufficient to remove all problems from a process. It implies that every such change or innovation also introduces its own share of new problems. The innovation of alpha contracting into the acquisition domain is no different. The key is to understand the relative advantages and disadvantages associated with a new change or innovation and appreciate the circumstances in which it is most likely to be successful and effective. In this section, we explore the relative advantages and disadvantages of alpha contracting.

Relative Advantages of Alpha Contracting

Alpha contracting provides a number of advantages. Summarizing from our discussion above, the alpha process can be described in terms of an investment. Both teams invest the time and attention of key personnel up-front to jointly develop contracting documents, with the objectives of: 1) improving communications; 2) decreasing the number of *formal* RFP iterations, revisions and rework required to correct misunderstandings, errors and mistakes; 3) reducing the cycle time (procurement administrative lead time or PALT) required for contracting; 4) increasing the level of trust, openness and mutual respect between the government and contractor teams; and 5) decreasing the overall cost—both for the Government and contractor—associated with the procurement. We briefly expand on each advantage in turn.

Improved communications. Alpha contracting involves a considerable number of *joint activities* performed by the buyer and seller, or Government and contractor in the typical federal acquisition. By performing procurement activities jointly, team members from both sides have frequent opportunities to communicate regarding a particular acquisition. This helps rectify misunderstandings, on both sides of the contract, and augments agreement and commonality of understanding between buyers and sellers. Further, alpha contracting generally decomposes large teams (e.g., representing the buyer and seller) into small ones (e.g., representing Engineering, Manufacturing, Materiel, Logistics, Pricing, Contracts), so that engineers can work directly with engineers, manufacturing people can work directly with manufacturing people, and so forth. This affords people, from opposite sides of the contract, to communicate directly and informally

with their peers and counterparts.

Decreased iterations. Improved communications promote common understanding between parties on opposite sides of the contract. A common understanding reduces the chances of misunderstandings, errors and mistakes propagating themselves into formal documents. Rather, where opportunities for such misunderstandings, errors and mistakes occur, members of alpha contracting teams can work together—directly and informally—to ask questions, challenge assumptions and test beliefs to ensure a common basis for proposing and contracting. If no misunderstandings, errors and mistakes are allowed to propagate into formal contractual documents, conceivably only one RFP and proposal are required to definitize a contract.

Reduced Procurement Administrative Lead Time. Each formal iteration of contractual documentation consumes time and resources. For instance, each time a RFP, proposal or other contractual document is revised, time and resources are required to change the document (e.g., through amendment, revision), gain internal approval (e.g., management review, legal review) and physically deliver the revised documents (e.g., mail, express delivery). Once received by the other party (e.g., the seller), additional time is required to understand the changes, make distribution through the contractor's organization and respond to the changes (e.g., through a revised proposal). Each such iteration consumes time and adds to PALT. It follows that PALT can be reduced by decreasing the number of iterations.

Increased trust. Increasing the level of trust, openness and mutual respect between the government and contractor teams stems from professionals working together in peer teams toward a common goal. Through such direct interaction, parties on both sides of the contract soon learn that deception is counterproductive, and by cooperating on various elements and phases of an acquisition, people on such peer teams learn to appreciate both the areas of agreement and disagreement between themselves and their counterparts. Understanding such areas up-front helps people on opposite sides of the contract focus on issues instead of personalities. It is much easier to work with someone who "disagrees" than one who "is trying to cheat," for example.

Decreased cost. Decreasing the overall cost—both for the Government and contractor—associated with a procurement is largely a function of reduced PALT above. But decreased cost also derives from the other factors above. For instance, improved communications reduce the cost associated with repeating, clarifying and justifying contractual documents. The preparation cost associated with multiple iterations of contractual documents can be reduced as each iteration is eliminated. And through increased trust, parties on both sides can reduce the amount of managerial oversight and review associated with a procurement. Notice that *reduced* oversight and review does not imply *no* oversight and review. Cost savings derive from the

reduction facilitated through increased trust.

Relative Disadvantages of Alpha Contracting

Alpha contracting provides a number of disadvantages as well. Principal among them are: 1) increased up-front resources; 2) negotiation difficulties; and 3) competitive sourcing complexities. As above, we briefly expand on each disadvantage in turn.

Increased up-front resources. We noted above the considerable number of joint procurement activities performed by buyer and seller. Joint work between buyer and seller can consume considerable time. For instance, the improved communications from above do not come without people on both sides of the contract investing the time to understand one another. And trust between people—particularly former contractual adversaries—requires time and positive reinforcement to develop. Moreover, the time required for alpha contracting occurs at the beginning of a procurement cycle (e.g., beginning with SOW/SOO development) and requires additional time and resources to plan and coordinate joint, alpha contracting sessions. It is not uncommon for major programs to send a dozen or more key people from a program office (e.g., the Program Manager, Contracting Officer, Chief Engineer) to spend weeks with their counterparts at a contractor's facility for alpha contracting meetings. Such key people tend to be very busy and overworked as it is. The *additional* demands of alpha contracting, over an extended period of time, represent a distinct disadvantage of this technique. Notwithstanding the opportunity for decreased PALT and reduced overall cost, the increased up-front resources required for effective alpha contracting can be prohibitive in the contracting office without foresight or some flexibility in scheduling resources.

Negotiation difficulties. Negotiation is often an adversarial activity, and the traditional, position-based negotiation rarely engenders trust and mutual respect between parties. Yet there are times during the contracting cycle—whether through traditional or alpha contracting—when disagreements and disputes cannot be resolved through cooperative discussion. When alpha contracting "teammates" attempt to settle such disagreements and disputes, the level of trust can be diminished and affect the ability of the associated individuals to continue working cooperatively. This is particularly the case when one party or the other feels disadvantaged through the result. Thus, alpha contracting appears to have a good place so long as the intensity of disagreements and disputes remains within a level that can be resolved cooperatively. Beyond this level, the alpha contracting process can breakdown. One strategy is to have as many issues resolved through alpha contracting as possible, and then shunt the remaining unresolved issues to formal negotiation at the bargaining table. A second strategy is management intervention in issues that cannot be resolved by the alpha contracting teams through cooperative discussion.

Competitive sourcing complexities. Alpha contracting is used almost exclusively for sole-source procurements. The demands of teaming noted above—particularly the up-front time and resource requirements—are challenging enough for the buyer to work cooperatively with a single contractor. In a competitive sourcing scenario, in which multiple competing contractors are involved, these challenges are exacerbated. Many program offices would simply find the up-front requirements prohibitively expensive and time-consuming to pursue alpha contracting with multiple vendors. Additionally, the same kinds and levels of trust developed between buyer and seller are unlikely to materialize between competing vendors. For instance, it would be unrealistic to expect even two firms, say which are competing for a single contract award, to share details associated with their product designs, technical approaches and costs. If a program office pursues alpha contracting with multiple vendors, it will probably have to establish separate government-contractor teams *with each vendor*. And the Government has duties not to share contractors' proprietary proposal information with their competitors, so each government team may need to involve different people from the program office. For instance, the engineer, cost/price analyst and contract specialist assigned to participate in an alpha contracting team for Vendor A may need to be different people than the ones assigned to participate in an alpha contracting team for Vendor B. This further exacerbates the resource constraints imposed by alpha contracting and complicates source evaluation and selection.

JSOW EXPERIENCE

As noted above, examination of alpha contracting as practiced on the JSOW program elucidates a number of strengths and weaknesses of this approach to acquisition reform. It is important to stress that although a number of factors make the JSOW program and alpha contracting process unique, none of the principles, tools or techniques described in this section is restricted to just the JSOW program. In other words, the JSOW experience is broadly applicable to a wide variety of different programs, systems and contracting situations. Here, we draw from Nissen (1998a) to outline some of the key contextual factors associated with the JSOW program and then summarize the key benefits realized by JSOW through alpha contracting.

JSOW Contextual Factors

At the time of our original field research (1998), the program had progressed very successfully through the Engineering and Manufacturing Development (EMD) contract for development of the Baseline (BLU-97) vehicle. And it was executing a Low Rate Initial Production (LRIP) Lot 1 contract for BLU-97 while in the midst of contracting for its second LRIP lot. Interestingly, JSOW contracting has not involved competitive

procurement since the EMD award. This is the primary reason for our emphasis on the sole-source contracting process. Further, the program elected to make a change in contract type for the current contracting cycle. Whereas the EMD and LRIP Lot 1 contracts were and are executed on a cost-reimbursement type contract (LRIP Lot 1 was originally priced as an EMD contract option), a fixed-price incentive (FPI) contract is contemplated for LRIP Lot 2. This change in contract type effects a substantial transfer of risk from the Government to the contractor and can produce a shift in the relative degree of cooperation versus confrontation experienced in alpha contracting. Also, the JSOW is categorized as an ACAT ID (i.e., major) DoD program and represents a complex, software-intensive weapon system that has not yet completed its operational flight test activities for *all* weapon system variants (i.e., BLU-108 and Unitary). These contextual factors can play an important role in decision making about alpha contracting.

The geographical separation between government project offices (Navy (USN) in California and Air Force (USAF) in Florida) and the contractor (Raytheon TI Systems (RTIS) in Texas) serve to exacerbate the up-front time and personnel commitments required for alpha contracting. Not only must a number of key personnel from the government PMOs and contractor team invest a substantial amount of time conducting the many, often-lengthy joint activities required to develop the technical, cost and contractual details associated with a solicitation, but the government teams are required to travel to the contractor plant location for the equivalent of several weeks, year after year. Thus, noting the alpha contracting process in general is expensive and time consuming, we find the geographic separation between the contractor and government PMOs compounds the costs and difficulties associated with joint proposal/contract development⁷. Although both the Government and contractor teams appear to be learning and improving the process from year to year, the current process continues to place heavy demands on the resources of both teams.

JSOW Alpha Contracting Benefits

The JSOW benefits derived from alpha contracting are difficult to quantify but very real. Although the cycle time for the contracting process is shorter through alpha contracting than through the baseline contracting process that came before, the program is also in a more mature stage of development (i.e., LRIP vs. EMD). Accordingly, the government and contractor team members now spend less time performing the alpha contracting process than its baseline counterpart. This allows key PMO and contractor personnel to concentrate their limited time and energy on the critical technical and programmatic aspects of weapon system acquisition, as opposed to a lengthy contracting cycle fraught with arms-length document exchange and rework. In today's environment of fiscal restraint and defense downsizing, the time and energy of key acquisition personnel represent severely constrained resources. Enabling these officers, executives, managers and engineers to concentrate on weapon system *development*, as opposed to administration, may

come to represent one of the most critical success factors identified to date. However, it is difficult to measure the quantifiable benefits stemming from such concentration of time and energy.

Further measurement difficulties arise from other benefits that include: improved quality of the contract documentation (which benefits contract administrators and program managers downstream after contract award); increased understanding by team members of key programmatic, technical and contractual issues that are surfaced and addressed early in the contracting cycle as opposed to late in the execution phase; and, the professional, trust-based relationships that are developed in the alpha contracting process and carry over to improve the character of work and atmosphere of cooperation that follows from contracting into program execution. These latter benefits represent important elements of the IPT process that are sought in modern government-contractor partnerships. The alpha contracting process appears to help foster such partnership before the execution phase of a program begins. This benefit can effectively help to move the government-contractor team along the IPT learning curve through joint participation, coordination and work in the contracting phase. Although this benefit too is difficult to quantify, such difficulty neither negates nor in any way diminishes its importance. As a closing note for this section, one (anonymous) long-term JSOW program participant summarizes the alpha contracting benefits as follows: "I believe the biggest benefit of IPTs, which allow for alpha contracting, is pride of ownership. All of the team members, government and contractor alike, hold the success of JSOW as a wondrous accomplishment of which they are all an important part."

ALPHA CONTRACTING DECISION MODEL

In this section, we use the preceding JSOW discussion as a point of departure for developing an alpha contracting model that can be used by PMs and KOs for process design and decision making. Drawing from Nissen (1998a), we reproduce a rough formalization of the Alpha Contracting Decision Model through the four quadrants and variables depicted in Table 1. It includes two dimensions: 1) locus of control (internal to the PMO or external), and 2) stability (fixed or variable across program phases).

Table 1 Alpha Contracting Decision Model

Locus of Control	Variable	Fixed
<u>Internal:</u>	(Quadrant I) Contract type Competition PMO commitment	(Quadrant II) Alpha experience Technical IPTs
<u>External:</u>	(Quadrant IV) Program phase Budget/schedule pressure Contractor openness	(Quadrant III) ACAT System Complexity Geography

Each of the four quadrants may be interpreted roughly as follows: 1) Quadrant I - recurring PMO decision variables (i.e., same variables may be revisited on each contracting cycle); 2) Quadrant II - fixed PMO decision variables (i.e., once decisions are made, these factors tend to remain fixed); 3) Quadrant III - fixed externally-imposed contextual factors (i.e., important, but outside PM direct control); and 4) Quadrant IV - externally-determined variables (i.e., variable, but not directly within PM direct control). PMO model use can be prescribed concisely: design and focus decision making on factors in quadrants I and II; understand, anticipate and react to factors in quadrants III and IV. Of course, the critical decisions are whether and when to employ alpha contracting.

Table 2 JSOW Alpha Contracting Process Scoring

Quadrant	Factor	Operationalization	LRIP Lot 1	LRIP Lot 2
QI:	Contract type	Cost vs. fixed price	+1	-1
	Competition*	Sole-source vs. competitive	+1	+1
	PMO commitment*	PM committed vs. ambivalent	+1	+1
Q2:	Alpha experience	Previous experience (yes vs. no)	-1	+1
	Technical IPTs	Currently employed (yes vs. no)	+1	+1
QIII:	ACAT	ACAT II/III vs. ACAT I	0	0
	System	Missile vs. other class	0	0
	Complexity	Simple vs. complex program	+1	+1
	Geography	Collocated vs. dispersed	-1	-1
QIV:	Program phase	Production vs. EMD	0	0
	Budget/Schedule pressure	Low vs. high	+1	-1
	Contractor openness*	Open vs. closed	+1	+1
Total Score:			+5	+3

Returning to our JSOW example for exposition, we summarize the simple scheme for scoring the likelihood of alpha contracting success on a particular program. Although this represents a preliminary scheme, which needs to be revisited and refined through additional research to address a number of other programs, it nonetheless provides useful information regarding the potential likelihood of alpha contracting success. To calibrate this model, we have rated the JSOW experience with alpha contracting using a simple ternary scale: a) score +1 if a factor *contributes* to alpha contracting success; b) score -1 if a factor *inhibits* success; and c) score 0 for factors *neutral* to alpha contracting success. The operationalization and scoring for JSOW alpha contracting (LRIP Lot 1 and 2) experience is summarized for factors in each quadrant through Table 2.

To illustrate from Quadrant I, the first factor listed in the table—contract type—is operationalized in terms of cost vs. fixed price. The score (+1) for LRIP Lot 1 is positive, because a cost-reimbursement contractual environment can ease contractor tension about cost risk. Although this simply shifts cost risk to the Government, absent a profit motive, the net effect can often improve the chances of successful alpha contracting through facilitated trust and cooperation. Conversely, the negative score (-1) for LRIP Lot 2

reflects the shift to a fixed-price contractual environment, which can impede alpha contracting efficacy. The assignment of scores to the other factors is relatively straightforward and follows similar reasoning and analysis. Briefly addressing the other factors listed under Quadrant I, we noted above several reasons why a sole-source environment is more conducive to alpha contracting than a competitive procurement, hence the positive score (+1) for JSOW. Next, the JSOW program office is committed to alpha contracting success and is willing to intervene to assure effectiveness. Such management support is important for effective joint work at lower organizational levels, and it enhances chances for alpha contracting success.

From Quadrant II of the table, we note alpha contracting represents a deviation from the traditional process, one that can benefit from practice and experience. For the JSOW program, the members had no such experience prior to LRIP Lot 1. This is the reason for the negative score (-1) for LRIP Lot 1. When Lot 2 began, the team then had the benefit of Lot 1 alpha contracting experience, hence the positive score (+1). Concurrent use of technical IPTs is also very beneficial to alpha contracting, because it affords an opportunity to integrate joint technical work (e.g., system engineering) with joint contracting work (e.g., SOW development), without having to change personnel or disrupt trust-based relationships. From the positive scores (+1), it is apparent the JSOW program benefited from such concurrent technical IPTs during both Lots 1 and 2.

Looking at the Quadrant III factors, we note no particular benefit or limitation of using alpha contracting that depends on a program's size and importance (e.g., ACAT designation) or the type of system being procured (e.g., missile, ship, tank, truck). Thus, these factors are scored neutrally (0) for JSOW. Alternatively, system complexity has a strong influence over alpha contracting success, for the alpha approach offers the greatest advantages over traditional contracting when applied to complex systems. This is the reason for the positive (+1) score for LRIP Lots 1 and 2. We noted above the problem with the large amount of up-front time required for alpha contracting. Geographically dispersed PMOs and contractor sites exacerbate this problem, so this factor is scored negatively (-1) for both JSOW lots. As a note, with foreign procurement, this negative score may need to be increased even further (e.g., to -2).

Moving to the Quadrant IV factors, as with system complexity, program complexity also drives alpha contracting success. EMD is notably more complex than production and follow-on phases, so we assign a neutral (0) score for LRIP Lots 1 and 2 (e.g., we would have scored higher (+1) in the EMD phase). Budget and schedule pressure also impact alpha contracting success. When such pressures are low, for example as in LRIP Lot 1, joint teams enjoy many degrees of freedom in designing a mutually-beneficial business deal and can often develop acceptable approaches and solutions without having to make difficult choices. When such pressures mount, however, affordable and effective programs often require higher-risk agreements, which are notably more difficult to reach through trust and consensus. Thus, we assign a negative score (-1) for this factor in LRIP Lot 2. Finally, contractor openness has an effect similar in size and direction to that of PMO commitment discussed above. Because the RTIS management was similarly committed to alpha contracting, we also score this factor positively (+1) for the JSOW program.

Notice from the table entries that the LRIP Lot 1 score of five exceeds the LRIP Lot 2 value by two points and is positive. We may propose a rough interpretation of this scoring scheme as follows: the higher the score, the greater the likelihood of alpha contracting success, and negative scores (i.e., below zero) may signal potential problems with the alpha approach. With this, the likelihood of success for LRIP Lot 2 could be interpreted as somewhat diminished with respect to that of LRIP Lot 1, yet still non-negative in value and relatively close (e.g., 2 points apart). Thus, relative caution may be required when employing the alpha approach on LRIP Lot 2. Further, the three variable factors from the table marked with asterisks—competition, PMO commitment, contractor openness—could shift to tilt the balance away from likely alpha contracting success in subsequent production lots.

CHAPTER 2 SUMMARY

The baseline or "traditional" contracting process is very prevalent within the DoD. For our purposes, the process begins with preparation of a statement of work and proceeds through contract negotiation. Multiple feedback loops occur at various points along the process flow, as few procurements are successfully completed without undergoing several iterations and revisions. A key point pertaining to the baseline process is, nearly all activities are performed *either* by the Government or contractor, but not both. In contrast, the overall pattern of the alpha contracting process flow differs considerably from that pertaining to the baseline (esp. in terms of process length, simplicity and collaboration), even though this latter, alpha version of the process accomplishes all of the same results required by its baseline counterpart above.

A key point is that the alpha contracting process involves many activities performed *jointly* by the government and contractor teams. Also, the alpha contracting approach can be described in terms of an investment. Both teams invest the time and attention of key personnel up-front to jointly develop these contracting documents. The investment has objectives that include: 1) improving communications; 2) decreasing the number of *formal* RFP iterations, revisions and rework required to correct misunderstandings, errors and mistakes; 3) reducing the cycle time (procurement administrative lead time or PALT) required for contracting; 4) increasing the level of trust, openness and mutual respect between the government and contractor teams; and 5) decreasing the overall cost—both for the Government and contractor—associated with the procurement. But alpha contracting provides a number of disadvantages as well. Principal among them are: 1) increased up-front resources; 2) negotiation difficulties; and 3) competitive sourcing complexities.

Examination of alpha contracting as practiced on the JSOW program elucidates a number of strengths and weaknesses of this approach to acquisition reform. It is important to stress that although a number of factors make the JSOW program and alpha contracting process unique, none of the principles, tools or techniques described in this section is restricted to just the JSOW program. The JSOW program

experiences many benefits (e.g., reduced PALT, improved communication, increased trust) as well as disadvantages (e.g., up-front time commitment, negotiation difficulties) of alpha contracting. The alpha contracting decision model, originally developed for the JSOW program, offers insight and an analytical tool for use by the contract manager to assess the likelihood of alpha contracting success.

CHAPTER 2 QUESTIONS

1. What is the principal difference between the manner in which work is performed in the baseline (i.e., "traditional") contracting process and its alpha contracting counterpart?
2. What are the key advantages expected through alpha contracting?
3. What are the key disadvantages expected through alpha contracting?
4. What factors from the alpha contracting decision model are within managerial control?

CHAPTER 2 ANSWERS

1. The principal difference lies in the joint performance of process activities in an alpha contracting approach.
2. Key advantages expected through alpha contracting include: 1) improving communications; 2) decreasing the number of *formal* RFP iterations, revisions and rework required to correct misunderstandings, errors and mistakes; 3) reducing the cycle time (procurement administrative lead time or PALT) required for contracting; 4) increasing the level of trust, openness and mutual respect between the government and contractor teams; and 5) decreasing the overall cost—both for the Government and contractor—associated with the procurement.
3. Key disadvantages expected through alpha contracting include: 1) increased up-front resources; 2) negotiation difficulties; and 3) competitive sourcing complexities.
4. Factors, both variable and fixed, within managerial control include contract type, competition, PMO commitment, alpha experience and use of technical IPTs.

Chapter 3 - Process Innovation

This chapter addresses process innovation. Here, we first introduce background information associated with reengineering and draw from Nissen (1996b) to highlight its key concepts through discussion of frequently asked questions. We focus in particular on one, important frequently-asked question pertaining to differences between process innovation—emerging from Business Process Reengineering (BPR) in the Nineties—and process improvement—emerging from Total Quality Management (TQM) in the Eighties. This discussion is followed by explanation of reengineering methodologies, techniques and tools and provides sufficient detail to guide direct application of process innovation techniques by contract managers. Specific examples are then employed to show how effective process redesign is accomplished through process innovation.

REENGINEERING BACKGROUND

Business Process Reengineering (BPR) is said to be entering its second phase (Cypress 1994). Through the approximate decade of its first phase, many disparate methodologies for process redesign were developed and employed, and a multitude of reengineering books (e.g., Davenport 1993, Hammer and Champy 1993) were published in the management press and widely read. During this time, nearly all large U.S. corporations engaged in major reengineering projects, and more than half of the annual reports to stockholders by *Fortune 500* companies addressed BPR activities in 1994 (Hamscher 1994). The Government, including many military commands, is also deeply involved in reengineering today.

In this first phase, the rise and fall of BPR in the trade press occurred, as the topic progressed from a state of perennial hype in the early Nineties (e.g., Anderson 1991, Currid 1994, Manager's Notebook 1994) only to be superseded by more recent focus upon topics such as the Internet, "Intranets," Java, and the like (e.g., Wilder 1995, Wilder et al. 1995, Marshall and Rodriguez 1995). During this first phase, a number of academic investigations were conducted to study the reengineering phenomenon (e.g., Stoddard and Jarvenpaa 1995), which exposed several "myths" (Davenport and Stoddard 1994) in addition to outlining many "preconditions for success" (Bashein et al. 1994).

The second phase promises to be more challenging than the first, particularly as the reengineering phenomenon continues to have negligible theoretical basis (Saharia et al. 1994). Described in terms of a shift from "customer value chain" analysis to a paradigm of "wealth creation and consumption" (Cypress 1994), the second phase will require more knowledge, better understanding, and more context-sensitive methodologies (Nissen 1996a) in order to avoid the same magnitude (e.g., 50-75%) of failure rates (Caron et al. 1994, Hammer and Champy 1993) ascribed to phase one. This chapter provides one such context-

sensitive methodology that has been successfully demonstrated both in the laboratory and through procurement reengineering projects in the field.

FREQUENTLY ASKED QUESTIONS

From its very likely beginning in the computer software industry, the FAQ (i.e., frequently asked question) file has become commonplace in both business and academe as an efficient method of knowledge transfer. Whether one is interested in learning about new software (e.g., Java 1996), technology (e.g., PowerBrowser 1996) or emerging phenomena such as electronic commerce (E-Commerce 1996), FAQ files are readily available and represent an excellent source of information with which to begin an investigation. That is the primary purpose of this section.

The "questions" themselves addressed by the FAQs that follow are determined primarily through participation in a number of reengineering and quality newsgroups and summarized in part through an informal poll of colleagues. Although in no way intended to be comprehensive, the "answers" below should serve to address many of the common questions pertaining to the phenomenon of BPR. Moreover, by drawing from the reengineering literature, these answers take-on a variety of perspectives and represent the knowledge and practice articulated by some of the best recognized authorities on process redesign. The questions and answers follow.

FAQ 1 - What Are the Key Terms and Concepts?

The reengineering literature represents an important source of terms and concepts. The term *reengineering* itself has been defined as, "... the *fundamental* rethinking and *radical* redesign of business *processes* to achieve *dramatic* improvements in critical, contemporary *measures* such as cost, quality, service, and speed [emphasis added]" (Hammer and Champy 1993, p. 32). The "fundamental" nature of reengineering relates to questioning assumptions; that is, taking nothing about a business or organization as fixed or given and challenging the appropriateness and existence of every aspect of business organization and operation. This is closely related to the accounting notion of *zero-based budgeting* (Cheek 1977) that was popular in the Seventies.

"Radical" redesign refers to transforming even the most enduring, stable and central aspects of a process design configuration and envisioning new redesign alternatives without limitations or constraints associated with a current design. "Dramatic" improvement implies the level of performance can increase by several fold (e.g., 2x, 5x), as opposed to marginal improvements that are generally measured in percentages (e.g., 5%, 20%).

The "measures" from above are associated with outputs, in terms of performance, as opposed to inputs to a business or organization. One issue relates to the fact that many outputs appear to be closely aligned, while others are surely oblique and orthogonal. For example, cost and cycle time (i.e., speed) appear to be closely related (Stalk and Hout 1990), as a reduction in cycle time corresponds to a decrease in allocated fixed or period costs. Reduced cycle time can also enable an increase in throughput or production. However, the relationship between cost (and cycle time) and quality or service is less clear.

For example, a common TQM precept suggests that improvements in quality correspond to decreased cost through the reduction of rework, returns, service and the like. Alternatively, higher quality output often requires the use of more expensive labor, materials and technology, which clearly correspond to higher costs. Further, superior quality and service represent techniques used for a strategy based on differentiation (Wiseman 1988), which is not generally associated with a cost-based strategy (Porter 1980). It seems clear that the "success" of a reengineering project will necessarily depend upon both the strategy being pursued and the output being measured.

Table 3 Key Reengineering Concepts

Topic	Concept
Reengineering	Fundamental rethinking, radical redesign, process, dramatic improvement, measures, return, risk
Process	Activities, customers, measures, work ordering, time, space, beginning, ending, inputs, outputs, structure, action, baseline
Redesign	Process configuration, design flaws, process transformation

Finally, from this definition, the "process" represents the central unit of analysis. The term *process* has been loosely defined as, "... a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer" (Hammer and Champy 1993, p. 35). From this definition, *activities*, *outputs*, *customers* and *measures* represent key concepts associated with processes. A similar definition appears in Davenport (1993, p. 5): "In definitional terms, a process is simply a structured, measured set of activities designed to produce a specified output for a particular customer or market." A related definition is found on p. 2: "A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action." This latter definition helps to identify additional key concepts, including *ordering of work*, *time*, *space*, *beginning*, *ending*, *inputs*, *outputs*, *structure* and *action*. These concepts are useful for building knowledge. Table 3 provides a summary of the key reengineering concepts identified in this FAQ.

FAQ 2 - How Does BPR Differ from TQM?

Based on our review of the literature, probably the most distinguishing feature between BPR and TQM is a matter of degree. This view is largely consistent with that expressed in Cole (1994, p. 81), in which an "extraordinarily large number of similarities between quality and re-engineering" is asserted. From the key terms and concepts above, the emphasis of the former is on singular and dramatic performance improvement through radical process redesign (Barnett 1994, Scherr 1993, Ward 1993), whereas more continuous and incremental gains are generally expected through the latter (Flood 1993, Hoffherr et al. 1994, Stein 1993). This view is echoed in Hammer and Champy (1993, p. 49): whereas "... quality programs and reengineering share a number of common themes" on the one hand, these authors also state that "the two programs differ fundamentally" and contrast the continuous, incremental nature of TQM with discrete, quantum effects of BPR.

The foundations of BPR are clearly set in TQM according to Harrington (1991), and in building upon this work, we are advised to "... combine process improvement and process innovation in an ongoing quality program" (Davenport 1993, p. 14). Alternatively, this same author describes the "pace of change" as much more dramatic in a reengineering project. A similar contrast also exists in Andrews and Stalick (1994), but their eight-step reengineering approach concludes with the transition to a CPI (i.e., continuous process improvement) environment.

However, there appears to be nothing in these expert reengineering methodologies that would prevent the gains achievable through CPI from becoming dramatic (i.e., of the same order as those sought through BPR). Neither would radical process redesign appear to ensure that improvements will exceed incremental levels (i.e., as BPR authors generally attribute to TQM), or even be positive for that matter. Analogous to the well known risk-return relationship captured in the Capital Asset Pricing Model (Sharpe and Alexander 1990), we are cautioned that "the risks of process innovation are at least proportional to the rewards" (Davenport 1993, p. 15). From the high BPR failure rates noted above, this suggests that reengineering represents a more aggressive, but riskier, performance-improvement endeavor than TQM.

The focus of measurement also differs in terms of emphasis between the BPR and TQM literatures. TQM publications, with their emphasis on CPI and Activity-Based Costing (Brimson 1991, O'Guin 1991), appear to reflect a relatively straightforward extension of traditional Industrial Engineering works such as Bailey (1982) or Barnes (1980). Some experts draw a contrast between this and "the new industrial engineering" (Davenport and Short 1990), in which the enabling power of IT is stressed. The role of IT in reengineering represents the subject of FAQ 5 below, but ex-ante process modeling (Curtis et al. 1992, Housel et al. 1993), complexity assessment (Albrecht and Gaffney 1983, Dreger 1989, Kanevsky and Housel 1994) and performance evaluation (Grady 1992, Nissen 1994) take on key importance in BPR.

To reiterate, differences between BPR and TQM may be best characterized in terms of degree (e.g., singular vs. continuous activity, dramatic vs. incremental improvement objectives, radical vs. "fine

tuning" process redesign). It would also appear that researchers in each area may have much to gain from their counterparts in the other, and practitioners who are familiar with TQM should catch-on quickly to BPR. This point highlights one of the intended contributions of this section: to capture and organize a major segment of the reengineering literature for the benefit of researchers and practitioners in BPR, TQM and other, relevant disciplines (e.g., Contract Management).

FAQ 3 - Why Reengineer Organizational Processes?

"The Crisis that Will not Go Away" is the title of Chapter 1 in Hammer and Champy (1993), in which the authors describe three forces that are driving companies to reengineer organizational processes: 1) customers taking charge, 2) competition intensifying globally, and 3) change perpetuating and increasing in pace. In addition to these external forces behind reengineering, the authors also highlight a problem internal to business processes themselves (p. 11):

Most companies today—no matter what business they are in, how technologically sophisticated their product or service, or what their national origin—can trace their work styles and organizational roots back to the prototypical pin factory that Adam Smith described in *The Wealth of Nations*, published in 1776.

Despite our common usage of the term *re-engineering*, such work styles and organizational roots do not appear to have been *engineered* to begin with. Rather, this suggests organizational processes are merely continuations of their predecessors, having evolved slowly and, in many cases, changed little through the decades (and centuries). Even if business processes had been engineered to begin with, say only ten or twenty years ago, a strong case could still be made for their re-engineering, particularly in light of "the tool that has changed business most over the past three decades—information technology" (Davenport 1993, p. 5). Not unlike the advent of electrical power near the turn of the century, information technology (IT) can enable entirely new methods of performing work.

Further, as noted above, reengineering has become very pervasive and important in business and government alike. The fact that nearly all U.S. corporations are undertaking major reengineering projects implies that a given company, which fails to reengineer, may fall behind simply by standing still. Management is adduced to simplify and streamline processes and to employ "breakthrough strategies" to effect error-free and world-class levels of process performance (Harrington 1991, p. 206). Management is also exhorted to strive for "breakpoint strategies" for renewed competitiveness and competitive dominance (Johansson et al. 1993, p. 119); here, the authors define a *breakpoint* as "... the achievement of excellence in one or more value metrics where the marketplace clearly recognizes the advantage, and where the ensuing result is a disproportionate and sustained increase in the supplier's market share" (p. 113). In terms of the Competitive Forces Model (Porter 1985), not only does reengineering represent a threat from rival

firms in a competitive arena, but BPR can also be characterized as an approach to the attainment of sustainable competitive advantage. Indeed, we have evidence that a number of companies view reengineering itself among their essential core competencies. Such companies include Cigna (Caron et al. 1994) and Taco Bell (Karlgaard 1994), for example.

FAQ 4 - What Reengineering Steps Are Required?

Each of the many expert reengineering methodologies is comprised of a somewhat different sequence of redesign activities or steps, which reflects differing emphases across the various methods. For example, one of the earliest of these (Rummler and Brache 1991) includes an analytical technique that helps one to focus upon who (i.e., what organizational role) is responsible for what (i.e., which process activities). Specifically, it involves a two-dimensional technique for process mapping, which builds upon the standard (one-dimensional) flowcharting approach employed in most methodologies. With this, the typical flowchart sequencing of tasks and activities is extended to incorporate the second dimension of organizational role; that is, it explicitly links process activities to the organizations and roles responsible for their execution. This represents the approach employed above to delineate the baseline and alpha contracting processes (e.g., in which government and contractor roles are clearly distinguished), for instance.

As noted above, another early expert reengineering methodology (Harrington 1991) has its focus upon process simplification and streamlining. It involves five steps: 1) organize for improvement; 2) understand the process; 3) streamline; 4) measure and control; and 5) continuous improvement (p. 21). As should be apparent from steps 2 and 4, this methodology places considerable emphasis on the understanding and measurement of an existing process baseline, respectively, to which some refer as the "as-is" condition or configuration. A similar emphasis on the baseline process configuration is found in the later methodology of Davenport (1993). This methodology outlines a sequence of five high-level activities, which are listed in Table 4, and highlights the importance of information pertaining to an existing process through step 4.

Table 4 High Level Reengineering Activities

Step	Activity
1	Identifying process for innovation
2	Identifying change levers (i.e., enabling technologies)
3	Developing process visions
4	Understanding and improving existing processes
5	Designing and prototyping the new process

This emphasis provides a stark contrast with the methodology of Hammer and Champy (1993), the latter of which involves "starting all over, starting from scratch" (p. 2). Indeed, in this latter methodology, analysis of an existing process baseline configuration is purposefully excluded, including instead only a

high-level understanding of "the what and the why, not the how, of the process" (p. 131). In a related work (Hammer and Stanton 1995, p. 19), the rationale provided is that "... the how is going to change anyway as a result of reengineering." The respective authors refer to this reengineering approach as "redesign with a blank sheet of paper" (p. 131) and "the proverbial clean slate" (p. 4). The importance of baseline process analysis represents a major issue of division between the expert reengineering methodologies. The method discussed in this chapter builds directly upon that of Davenport. The author feels the early practice of redesigning processes without first understanding their baselines contributed substantially to the high BPR failure rates experienced in the first phase.

Table 5 Critical Redesign Activities

Phase	Redesign Activity
4 - Understanding and improving existing processes:	<ol style="list-style-type: none"> 1. Describe the current process flow 2. Measure the process in terms of the new process objectives 3. Assess the process in terms of the new process attributes 4. Identify problems with or shortcomings of the process 5. Identify short-term improvements in the process 6. Assess current information technology and organization
5 - Designing and prototyping a new process:	<ol style="list-style-type: none"> 1. Brainstorm design alternatives 2. Assess feasibility, risk and benefit of design alternatives 3. Select the preferred process design 4. Prototype the new process design 5. Develop a migration strategy 6. Implement new organizational structures and systems

Returning to the methodology of Davenport (1993), each of the five high-level reengineering activities listed in the table above can be decomposed into a set of lower-level activities. Focusing, for example, upon the elements of process *redesign*, steps four and five detail the requisite reengineering activities. Table 5 contains a listing of the second level activities corresponding to steps four and five. Through its inclusion of baseline process analysis and measurement, this methodology effectively subsumes that of Harrington (1991) above, and it is quite comprehensive. However, although this present framework effectively prescribes *what* reengineering activities to perform, and in which order they should be accomplished, it fails to describe *how* to perform them (i.e., is not operationalized). This represents a common theme that pervades the expert reengineering methodologies is addressed directly through this chapter.

A subsequent methodology (Andrews and Stalick 1994) also outlines a multi-step sequence of reengineering activities. Unlike its counterparts above, greater emphasis is placed on implementation, as opposed to redesign. Implementation represents a key stage of activities in the reengineering life cycle (see Guha et al. 1993, Kettinger et al. 1995), and it represents a major area of risk in terms of BPR success. The eight steps are listed in Table 6. As noted above, this methodology calls for transition to a CPI environment.

Such institutionalization of process improvement is also noted as important in Davenport (1993, p. 14): "Lest it slide back down the slippery slope of process degradation, [following process redesign] a firm should then pursue a program of continuous improvement for the post-innovation process." Again, the consensus among reengineering experts suggests that BPR and TQM are both compatible and complementary.

Table 6 Eight Step Approach

Step	Activity
1	Frame the project
2	Create vision, values and goals
3	Redesign business operations
4	Conduct proof of concept
5	Plan implementation
6	Get implementation approval
7	Implement redesign
8	Transition to CPI environment

FAQ 5 - What is the Role of Information Technology?

As noted above, information technology has had a profound effect on business and government processes. For a number of years, researchers have investigated the role of IT in BPR (e.g., Smith and McKeen 1993, Teng et al. 1992), employed IT-based analytical techniques (e.g., Daniels et al. 1991, Dennis et al. 1993) and developed frameworks to characterize reengineering in terms of how IT is strategically employed (e.g., Ives et al. 1993, Venkatraman 1994). In the expert reengineering methodologies, IT is consistently described as *the central* enabling technology for process redesign.

For example, IT is called the "*essential enabler*" in reengineering (Hammer and Champy 1993, p. 83), and management is urged to "think inductively" (p. 84) about how IT can be employed for process redesign. Such inductive thinking begins with known information technologies, such as those listed in Table 7 (pp. 91-101), which managers use to identify problems the technologies can help to solve. Although the authors caution against an over-reliance on IT in reengineering—colorful terms such as *automating the mess* and *paving the cowpaths* have been used (Hammer 1990) to describe this situation—it is clearly central to their methodology.

Table 7 IT Enablers

Example	Enabler (i.e., transformation technology)
1	Shared databases
2	Expert systems
3	Telecommunications networks
4	Decision support tools
5	Wireless data communication and portable computers
6	Interactive videodisk

IT also plays a key role in the methodology espoused in Davenport (1993): "... information technology [is] ... the most powerful tool for changing business to emerge in the twentieth century." However, this author also acknowledges the importance of other enabling or transformation technologies (p. 13), to which he refers as "human and organizational development approaches." This mirrors a key concept from information systems that dates back to the early introduction of IT in business. For instance, Leavitt (1965) indicates that management cannot simply introduce IT into a process. Rather, people, tasks, structure and technology must all be changed together, or at least considered. Indeed, Davenport (1993, p. 13) proceeds to state that "... information technology is rarely effective without simultaneous human innovations."

Another view of IT's role in process redesign is provided by this same author, in terms of the nine *effects* that can be produced through IT (p. 51): 1) automational, 2) informational, 3) sequential, 4) tracking, 5) analytical, 6) geographical, 7) integrative, 8) intellectual, and 9) disintermediating. As an example from the emerging phenomenon of electronic commerce, IT is now employed to enable consumers to book airline flights directly (i.e., without the services of a travel agent) through the Internet World Wide Web (Southwest Airlines 1996); that is, one effect of "Web" technology has been to disintermediate the airline flight-booking process.

BPR FAQs Summary

The five BPR FAQs are listed in Table 8. To summarize briefly, FAQ 1 provides the key terms and concepts associated with the phenomenon of reengineering. Central among these is the process as the fundamental unit of analysis in BPR and the focus upon dramatic performance improvement through radical process redesign. FAQ 2 addresses the similarities and differences between BPR and TQM. Despite differences in terms of scale, scope and risk, BPR and TQM vary predominately in degree and represent both compatible and complementary endeavors.

Table 8 BPR FAQs Summary

FAQ	Summary
FAQ 1	Key terms and concepts?
FAQ 2	BPR & TQM differences?
FAQ 3	Why reengineer?
FAQ 4	Reengineering steps?
FAQ 5	IT role?

FAQ 3 follows directly from FAQ 2, in much the same manner that the BPR phenomenon of the

Nineties followed the TQM movement that originated in the Eighties; that is, by asking the question, if we have TQM, why reengineer organizational processes? The myriad perspectives circle around the issue of competitiveness—firms reengineer either to keep up with performance improvements effected at rival firms or to attain competitive advantages of their own.

FAQ 4 outlines the key steps from a number of expert reengineering methodologies, from which a divisive issue pertains to the need for analysis of an existing process before redesigning it. Some experts note the importance of information that can be obtained through baseline analysis, whereas others exhort management to skip this step and pursue a "clean slate" or "blank sheet of paper" approach. Of the methodologies that stress baseline process analysis, measurement is assigned a very important role. However, the nature of measurement in IT-enabled process redesign has a different emphasis from previous measurement focuses in TQM.

Finally, FAQ 5 addresses the role of IT in process redesign. Although IT is heralded as the central enabling technology for reengineering, the experts caution against the sole or excessive reliance on this transformation technology, and other enablers of process innovation such as human and organizational interventions are adduced. And drawing from Leavitt, we are reminded that one cannot simply introduce IT into a process and expect the kind of dramatic performance improvements sought through reengineering. The colorful characterizations "automating the mess" and "paving the cowpaths" provide vivid reminders of this longstanding expert advice.

MEASUREMENT-DRIVEN PROCESS INNOVATION

In this section, we outline a general redesign process, as delineated in Figure 3, and use it to describe a practical, measurement-driven approach to process innovation. To show how this process innovation approach is used, we draw from Nissen (1998b) and employ it to redesign a commercial reengineering case from the literature.

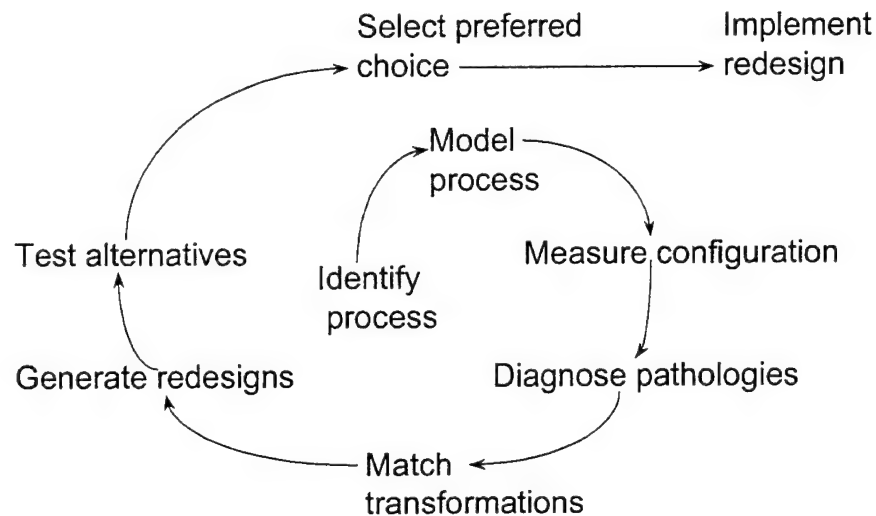


Figure 3 General Redesign Process

The sequence of process-redesign activities delineated in Figure 3 represents a blend of expert reengineering methodologies—particularly those of Andrews and Stalick (1994), Davenport (1993), Hammer and Champy (1993), Harrington (1991) and Johansson et al. (1993)—synthesized together to compose an analytical method supporting measurement. The path through these steps is delineated as a spiral in the figure, which represents a common notation for evolutionary processes (see Boehm 1988 for discussion pertaining to software engineering).

Step one is to identify a target process for redesign. Next, a model is constructed to represent the baseline (i.e., “as is”) configuration of this process, and configuration measurements then drive the diagnosis of process pathologies. The diagnostic results are used in turn to match the appropriate redesign transformations available to “treat” pathologies that are detected. This sequence of analytical activities leads systematically to the generation of one or more redesign alternatives, which most experts argue should be tested through some mechanism (esp. simulation) prior to selection of a preferred alternative for implementation. This, baseline process is characteristic of first-generation redesign methods and tools, through which the three key intellectual activities—process measurement, pathology diagnosis and transformation matching—are performed manually at present. We succinctly expand on each step in turn below.

Identify Process for Redesign

Reengineering experts such as Davenport (1993, p. 27) advise that "major processes" with "strategic relevance" should be targeted for redesign, and according to Hammer and Champy (1993, p. 122), heuristics for process selection include factors such as "dysfunction," "importance" and "redesign feasibility." Although this chapter does not address the process-identification step per se, the measurement-driven redesign approach discussed in this section is oriented toward processes that involve knowledge application and information flows (e.g., "office work"). This orientation imposes two requirements: 1) that the process is stable, and 2) that the constituent work activities are understood well enough to support representation in terms of a process model. Thus, if a process is not repeatable (e.g., ad-hoc or single-shot work activities) or participants are unable to describe how the process is performed in terms of its constituent tasks (e.g., creative work, scientific discovery), it is probably inappropriate for measurement-driven redesign. As a note, procurement and contracting activities fit the description of knowledge and information work very well.

Develop Process Model

Development of a process model represents a standard reengineering practice recommended by experts (e.g., see Davenport 1993, Harrington 1991), and process modeling is well supported by first-generation redesign tools. We take advantage of the fact that most process models developed in practice are now graphical and computer-based (see Curtis et al. 1992). A graphical process model represents the starting point for measurement-driven redesign. Figure 4 illustrates an example process model used for outlining the associated techniques. This process involves four tasks (A, B, C, D) and three work objects (doc1, doc2, doc3). Each process task is represented by a node in the graph, which is linked by a directed edge to exactly one other task in a simple, linear process flow. Process attributes are shown below each activity node. For example, Task A has three attributes shown: 1) activity name ("Check"), 2) role of the assigned agent ("Check-agent"), and 3) IT resource used for support ("DBMS"). The same follows for the other three process activities.

Redesign Modeling Example. We introduce an example from the reengineering literature to help elucidate the techniques. The particular example delineated in Figure 4 represents a snippet of workflow activities adapted from the well-known credit financing process described by Hammer and Champy (1993, pp. 36-39). Here the first task is associated with performing a credit check and is accomplished by a specialist (denoted by a specific role: Check-agent) supported by a database (DBMS). Similarly, another specialist agent (Price-agent) performs the pricing task using a decision support system (DSS), followed by a third specialist (Terms-agent) who composes the appropriate terms and conditions for financing using a word processor. A manager agent is

included at the end of this example to review the financing package, and a feedback or quality loop is indicated to denote a path for rework. This notation also indicates that a separate document is created at each of the first three task nodes (e.g., doc1 is created at Task A; doc2 is created at Task B) and that all three documents flow to the end node at Task D. We continue with this example throughout the section.

Measure Process Configuration

Process measurement requires a set of process measures. Process measures are drawn from fields such as Statics (e.g., measures including length, breadth and depth), Artificial Intelligence (e.g., variables such as problem size, parallelism/decomposability and feedback/cycles), Information Systems (e.g., uses of IT such as support, communication and automation) and others (e.g., Coordination Theory, Organizational Behavior, Total Quality Management). Notice these fields are independent from reengineering-specific methods and cases. We stress such independence as a knowledge engineering technique to increase the robustness of measurement-driven redesign. A detailed description of this measure-development process can be found in Nissen (1996b).

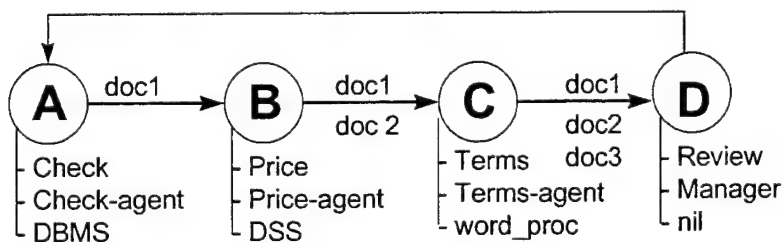


Figure 4 Example Process Model

We should note this set of measures is not intended to be complete at this point. Rather, the idea is to develop a relatively-small, fundamental set and examine the use of such measures to drive redesign analysis,

particularly in terms of their heuristic value for diagnosing process pathologies. Nonetheless, the ability of a few, fundamental measures to support the development of a robust analytical capability is well known. In the physical sciences, for example, nearly all measurement in physics, engineering and like disciplines can be traced to a set of just *six*, fundamental measures—charge, temperature, mass, length, time and angle (Krantz et al. 1971).

Our measurement technique requires each process measure to be operationalized explicitly using the node, edge and attribute constructs from above. For instance, process length is defined as the number of task nodes connected together in the longest path through the process model; process breadth is defined as the number of distinct paths through the representation; and so forth. Procedures for dealing with branch nodes, cycles and multiple levels of decomposition are straightforward (e.g., count the longest OR branch for measuring process length; count the steps associated with a cycle once). Consistency of application represents a more important factor than selecting any one procedure over another (esp. to support comparative process analysis). A set of example process measures is presented in Table 9, along with their corresponding graph-based definitions.

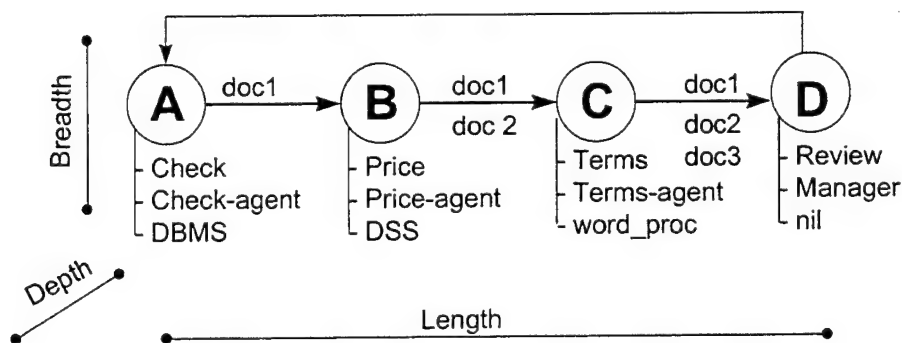
Table 9 Example Process Measures

Measure	Graph-Based Definition
Process Length	Number of nodes in longest path
Process Breadth	Number of distinct paths
Process Depth	Number of process levels
Process Size	Number of nodes in process model
Process Feedback	Number of cycles in graph
Parallelism	Process Size divided by Length
IT Support	Number of IT-support attributes
IT Communication	Number of IT-communication attributes
IT Automation	Number of IT-automation attributes
Organizational Roles	Number of unique agent role attributes
Process Handoffs	Number of inter-role edges
Organizations	Number of unique agent organization attributes
Value Chains	Number of unique activity Value Chain attributes

Redesign Measurement Example. The credit financing model from above is continued in Figure 5, this time with example process measurements based on definitions from the table. For instance, we see the process is four steps long (i.e., length = 4), has one path through it (i.e., breadth = 1) and is represented at a single hierarchical level (i.e., depth = 1). Process size (4) accounts for the four activities, and the one feedback loop is counted (feedback = 1). Interestingly, the parallelism measurement ($1.00 = 4/4$) represents a theoretical minimum for this measure. Notice how this minimum parallelism (i.e., maximum linearity) reflects the serial layout and linear appearance of the process. The IT measurements are taken from corresponding IT attributes in the model (e.g., the DBMS, DSS and word processor each count toward the IT-support value of 3). Using this example, we show how such process measures can be used to drive the automatic diagnosis of pathologies.

Diagnose Process Pathologies

To develop a measurement-driven diagnostic capability, we introduce a taxonomy of process pathologies to be used for classification of problems and shortcomings. This taxonomy formalizes some of the deep reengineering knowledge required for process redesign. The idea is to use process configuration measurements to detect and classify a variety of common process pathologies. The taxonomy is constructed from the BPR literature, as classes and instances of pathologies are synthesized from the various process problems and shortcomings noted in the expert reengineering methodologies from above (e.g., Andrews and Stalick 1994, Davenport 1993). The problematic conditions described in the many published redesign cases (e.g., Goldstein 1986, King and Konsynski 1990, Stoddard and Meadows 1992, Talebzadeh et al. 1995) are similarly used to organize and populate the taxonomy. As with the set of process measures above, the present taxonomy is intended to be representative and extensible, not necessarily complete. The class-level taxonomy of process pathologies is presented in Table 10, along with a sample instance from each of the ten classes.



Measurements

Length = 4 Breadth = 1 Depth = 1
 Size = 4 Feedback = 1 Parallelism = 1.00
 IT-support = 3 IT-communication = 0 IT-automation = 0

Figure 5 Example Process Measurements

Many of the process measures from above can be used to detect pathologies set forth in this taxonomy. For example, the first listed class, "problematic process structure," refers to problems stemming

from the layout of process workflows. The corresponding sample instance, "sequential process flows," is widely noted in the reengineering literature as problematic (e.g., see Hammer and Champy 1993, p. 54), particularly with the associated implications in terms of cycle time for a process. Notice from above the *parallelism* measure can be used to detect this process pathology; that is, a (low) parallelism measurement quantifies the extent to which a process structure is laid-out in terms of sequential workflows.

As another example, the bureaucratic organization is likewise widely noted in the reengineering (and quality) literature as problematic (e.g., see Hammer and Stanton 1995, Flood 1993, Hoffherr et al. 1994). Bureaucratic problems are noted as being particularly severe in terms of maintaining a specialized workforce (i.e., "job specialization") and cycle-time delays associated with fragmented work handed-off from one functional organization to another (i.e., "process friction"). The *organizational roles* and *process handoffs* measures from above can be used to detect these respective process pathologies; that is, a (high) roles measurement quantifies the extent to which an organizational design reflects job specialization, and a (high) handoffs measurement similarly signals fragmented process flows and the associated friction. As a third example, inadequate IT infrastructure is probably the most-widely noted process pathology in the reengineering literature, as deficiencies in this area such as low IT support (i.e., "manual processes") and paper-based communications have implications that include cost, cycle time, quality and many other performance objectives. Notice from above that the *IT Support* and *IT Communication* measures can be used to detect these process pathologies.

Table 10 Taxonomy of Process Pathologies

Pathology Class	Sample Instance
Problematic process structure	Sequential process flows
Bureaucratic organization	Job specialization
Fragmented process flows	Process friction
IT infrastructure	Manual process
"Checking" approach to quality	Review-intensive process
Centralized authority	Long decision chains
Under-utilized human potential	Training emphasis
Inhibitive leadership	Directive supervision
Centralized information	Central database architecture
Deficient core competency	Low IT expertise

Despite the promising diagnostic potential seen in these three examples, however, not all pathologies correspond to measures that offer the same level of diagnostic capability. This is because the taxonomy and associated measures are developed independently and from separate sources of literature. As two cases in point, we have yet to develop measures to detect the "training emphasis" and "directive supervision" pathologies listed in Table 10. This highlights a weakness of measurement-driven redesign; not all heuristically-valuable diagnostic concepts can be operationalized in terms of graph-based measures.

Redesign Diagnosis Example. Referring back to Figure 5, we noted the parallelism measurement (1.00)

reflects the serial layout and linear appearance of the process and indicated its unit value represents a theoretical minimum; that is, the graph-based measure is defined such that a process cannot have measured parallelism lower than unity. This implies that a process with unit parallelism is *absolutely* linear or sequential, by definition. Thus, measurement-driven redesign can infer a process measured with unit parallelism suffers from the pathology "sequential process flows," an instance of the class "problematic process structure." This example is representative of the diagnostic approach employed in measurement-driven redesign. Inference based on other measures and pathologies is performed in a like manner and can be accomplished through straightforward, rule-based reasoning. For example, using Structured English for clarity, a simple IF-THEN rule can be written to classify this pathology directly.

```
IF parallelism = 1.00  
THEN pathology = "sequential process flows"
```

A more interesting situation arises when the measured value for a dimension does not correspond exactly to an extremum, as would be the case with a parallelism value above this minimum (e.g., 2.00, 3.37). In such a situation, benchmarking or like information that is specific to a particular domain, industry or process family is required to calibrate the measurement gauge. For example, a measured parallelism value of 2.00 certainly indicates a process that is more parallel than the one diagrammed in the figure above, but for diagnostic purposes, we need to know whether this degree of parallelism is pathological or not. This is where the domain-specific benchmarking information is employed. In the case of credit financing, for example, say best organizational performance in the industry corresponds to parallelism of 3.33. The rule from above can be extended to incorporate such benchmarking information.

```
IF parallelism < 3.33  
AND process family = "credit financing"  
THEN pathology = "sequential process flows"
```

Alternatively, the rules can be written with symbolic values such as "high" and "low," which may help simplify the discussion. For example, the rules above can be restated as follows.

```
IF parallelism = "low"  
THEN pathology = "sequential process flows"  
  
IF parallelism < "medium"  
AND process family = "credit financing"  
THEN pathology = "sequential process flows"
```

Application of the other process measurements to classify pathologies follows a similar approach.

Match Redesign Transformations

To develop a measurement-driven matching capability, we introduce a taxonomy of redesign transformations to be used for matching with pathologies. This taxonomy formalizes additional, deep reengineering knowledge required for process redesign. The idea is to use the measurement-driven, diagnostic information from the steps above to match appropriate transformations. This taxonomy is also constructed by drawing from the BPR literature, as classes and instances of redesign transformations are synthesized from the various enabling technologies, organizational changes, workflow modifications and like interventions noted in the expert reengineering methodologies. Redesign transformations described in the many published BPR cases are similarly used to organize and populate the taxonomy. The class-level taxonomy of redesign transformations is presented in Table 11 along with a sample instance from each of the seven classes.

The first class of redesign transformations is labeled “workflow reconfiguration.” This class pertains to process changes that simply rearrange the layout of workflows; in other words, they affect the sequencing of process activities and flow of work, but not how or by whom the activities are performed. Process de-linearization—rearranging serial process activities to be performed more in parallel—represents one example of a transformation from this class. The addition of a “triage step” (see Hammer and Champy 1993, p. 55), for example, would also fall into this class. Similarly, a shared database system represents an instance from the IT transformation class, as are decision support systems, local area networks and like information systems and their associated infrastructure. In fact, most of the IT-based enabling technologies cited throughout the reengineering literature (e.g., see Hammer and Champy 1993, pp. 92-99) would fall into this second class of transformations. Other transformations, such as organizational design changes associated with instituting a case manager position, follow the same class-instance structure of the taxonomy.

Table 11 Taxonomy of Redesign Transformations

Transformation Class	Sample Instance
Workflow reconfiguration	Process de-linearization
Information technology	Shared database system
Organizational design	Case manager
Human resource	Team-based compensation
Information availability	Informate agents
Inter-organizational alliance	Supplier-managed inventory
Management & culture	Employee stock ownership

Redesign Matching Example. Referring again to the measures presented in Figure 5, we noted the unit (i.e., “low”) parallelism measurement drives inference to diagnose the pathology “sequential process flows.” As above, a straightforward rule can be written to match this pathology with an appropriate transformation. The relevant diagnostic measurement is noted next to this rule for reference.

IF pathology = "sequential process flows" (parallelism = 1.00 or "low")
THEN redesign transformation = "de-linearization"

Other pathologies and recommended redesign transformations for the credit financing case follow from similar rules. It is interesting to note several of these latter transformations correspond to the redesign interventions actually recommended and employed in the credit financing case described by Hammer and Champy. For example, the "case manager" recommendation can be obtained directly from measurement-driven redesign.

IF pathology = "job specialization" (roles = 4 or "high")
AND pathology = "process friction" (handoffs = 3 or "high")
THEN redesign transformation = "case manager"

Matching of the other pathologies to redesign transformations follows a similar approach.

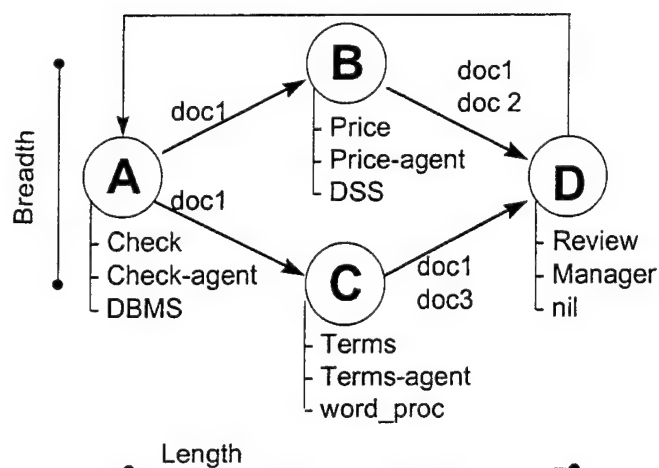
Generate, Test and Select Redesign Alternatives

Regarding generation of alternatives, each redesign transformation from above is tantamount to a consultant-like recommendation for process change. Applying one or more of the redesign transformations matched by measurement-driven redesign produces the corresponding alternative (i.e., "to be") process models intended to improve process performance. For example, a redesign alternative generated by measurement-driven redesign for credit financing is shown in Figure 6 as the result of applying the "de-linearize" transformation to tasks B and C (serially independent). We should note this, cycle-time reducing transformation is not even mentioned in the case.

Simulation-based testing is useful to compare the relative performance associated with multiple, competing redesign alternatives—prior to implementation—and it represents a powerful analytical method that is particularly useful for evaluating alternatives that are either too expensive or time-consuming to test physically (Law and Kelton 1982). Simulation represents a well-established area of study, supported by an abundance of methods, tools and experience. When care is taken to validate simulation models against the performance of their physical counterparts in operational processes, the results can be quite dependable (see Bitauld et al. 1997, van Mael 1993, van Mael et al. 1995). An even greater abundance of decision methods, tools and experience is available to guide and support the selection of a preferred redesign from multiple alternatives, the final redesign step.

To summarize, through measurement-driven redesign, we capture and formalize deep reengineering knowledge and specialized redesign expertise and develop a second-generation BPR tool to automate three, time-consuming intellectual redesign activities—process measurement, pathology diagnosis and transformation matching. In this section, we see how measurement-driven redesign applies its knowledge and expertise to redesign a credit financing process and note that its generated recommendations match several of the redesign

transformations actually employed in the case. Measurement-driven redesign even recommends promising transformations (e.g., de-linearizing sequential activities) not mentioned in the case. This highlights some of the power and potential of the approach.



Measurements

Length = 3 Breadth = 2 Depth = 1
 Size = 4 Feedback = 1 Parallelism = 1.33
 IT-support = 3 IT-communication = 0 IT-automation = 0

Figure 6 Redesign Alternative ("to be") Model

PROCUREMENT PROCESS REDESIGN

This section examines use of the process innovation approach above to redesign procurement processes. Specifically, we draw from Nissen (1998b) to show how innovation can be employed for a process frequently encountered in acquisition: Justification and Approval.

Justification and Approval Process

We begin with Justification and Approval (J&A), a relatively small but complex procurement process that is insightful for discussion. The J&A process is involved with all sole-source or "other than full and open competition" procurements in the Government, and it is expressly required by regulation. Although not a large process, it is quite complex and has been identified by senior procurement officials as particularly important and dysfunctional. Recall that factors such as importance and dysfunction are noted above as useful heuristics for identifying processes to be redesigned. A level-1 baseline process model for J&A is

presented in Figure 7.

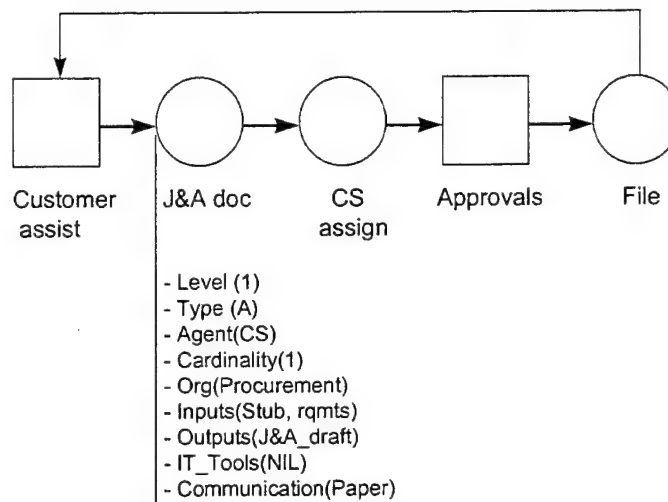


Figure 7 J&A Level-1 Baseline Process Model

At this top level, the process is comprised of five tasks: 1) Customer assistance, 2) J&A documentation, 3) Contract Specialist (CS) assignment, 4) Approvals, and 5) J&A filing. Notice the process is entirely sequential, with each activity following a single predecessor in linear fashion. A feedback or quality loop is used to represent rework that results from disapproval of a J&A documentation package. Several familiar process attributes (e.g., agent, organization, IT tools) and values are listed below the "J&A doc" task in the figure, for instance. To avoid cluttering this particular diagram, we have omitted corresponding attributes for the other process activities from Figure 7. These attributes correspond to those discussed in the context of the credit financing case. The figure also includes some measurement-driven redesign extensions (e.g., inputs, outputs, communication) to the set discussed above. In this representation, the circle icons represent atomic tasks that are not decomposable, and the square icons represent decomposable workflows that are comprised of lower-level subprocesses. Both the customer assistance and the approvals tasks are comprised of lower-level workflows in this manner. In fact, the approvals workflow has two hierarchical levels beneath it (for a total process depth of 3 levels; not shown).

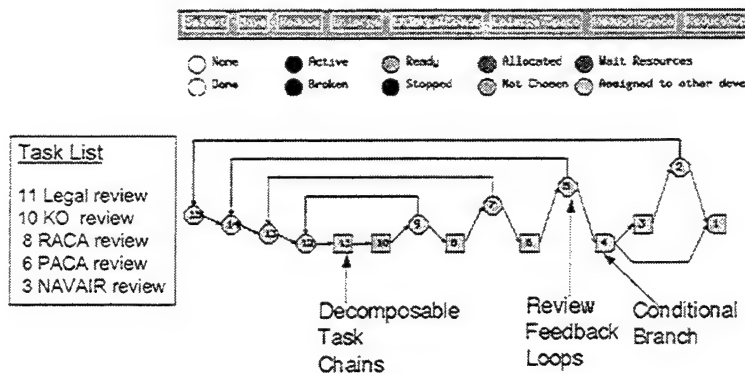


Figure 8 J&A Level-2 Baseline Process Model - Approvals

Figure 8 depicts the level-2 baseline process model comprising the approvals workflow. Here the figure represents an annotated “screendump” from a different modeling tool. Here, the hexagonal nodes represent starting and ending points for feedback loops, which differs somewhat from the notation in Figure 7 above. As can be seen from the level-2 approvals diagram, the workflow consists of four, sequential J&A reviews. Briefly, the J&A documentation is first reviewed by an agent from the Legal Department, who may or may not approve it. If approved, the J&A package proceeds to the next review, whereas in the latter case it is returned for rework. After Legal approval, the J&A package is reviewed by the Contracting Officer (KO), who similarly may either approve it or remand it for rework. We note the review by one agent (e.g., the KO) is not dependent upon the results of the preceding review (e.g., Legal). The linear review process continues in this fashion with the J&A package then sent for review by competition advocates from the requiring activity (RACA) and procurement activity (PACA). The RACA and PACA roles emerged from the Competition in Contracting Act (CICA), and assigned personnel perform an important function by scrutinizing J&As and promoting competition. A conditional branch in the workflow demarcates an additional process step required to obtain senior management approval of J&As above a certain dollar threshold.

Measurement, Diagnosis and Matching

Some of the more illustrative configuration measurements are summarized in Table 12 for the J&A process along with the corresponding diagnoses. Note the “small” size does not represent a pathology per se. The process size (31), organizational roles (7) and parallelism (1.00) measurements are computed in the same manner described for the credit financing example, as are the familiar length (31), breadth (1), depth (3) and other parameters (not shown). And the roles measurement (7) receives the same interpretation (i.e., narrowly-defined job scope) as above in the credit financing case. Alternatively, the three IT “fractions” differ somewhat from the corresponding IT “counts” analyzed in the credit financing case. Specifically, these fractional measurements are calculated by dividing process-size (31) into the counts for IT-based support (1), communication (0) and automation (0), respectively. Such scaling (e.g., dividing IT counts by process size) improves inter-process comparability and makes the measurement-driven method more robust to differences in process size.

Table 12 J&A Configuration Measurements and Diagnoses

Configuration Measure	Value	Diagnosis
Process Size	31	Small process
Organizational roles	7	Job specialization
Parallelism	1.00*	Sequential process flows
IT-Support fraction	0.03	Manual process
IT-Communication fraction	0.00*	Paper-based process
IT-Automation fraction	0.00*	Labor-intensive process
Feedback fraction	0.35	Review-intensive process
Handoffs fraction	0.58	Process friction

* denotes theoretical extremum for a measure

For instance, the same measurement-driven redesign rules that are used for diagnosing the J&A process (i.e., with size of 31) apply equally well to Major Procurement (e.g., with over 800 modeled process tasks). Note the values for parallelism and these measured IT fractions are at or near their theoretical minima (extrema are denoted by asterisks in the table). This indicates the baseline J&A process configuration is not only sequential but highly manual, paper-based and labor-intensive as well. Likewise, the feedback fraction (0.35) highlights the review-intensive nature of the process, and the handoff fraction (0.58) similarly underscores the substantial process friction.

The eight recommended redesign alternatives are summarized in Table 13 along with the matching pathologies for reference. Notice several of these pathology-transformation combinations correspond to similar measurement-driven redesigns discussed in the context of credit financing. For example, the pathology “sequential process flows” is matched with the de-linearize redesign transformation. Notice in the present instance the de-linearization transformation is targeted explicitly toward the approvals workflow. This targeting results from the high feedback-fraction measurement, which helps measurement-driven redesign to focus on the approvals portion of the process.

The de-linearization transformation is used in turn to generate two, similar but distinct redesign

alternatives: 1) concurrent reviews, and 2) joint reviews. The first alternative involves asynchronous reviews conducted in parallel as opposed to serially (e.g., each reviewer receives an identical J&A documentation package from the CS), whereas the second alternative requires contemporaneous (i.e., joint) meetings by the participants to review the J&A documentation. Likewise, low IT support for a frictional, document-based process drives the same shared database transformation implemented in the credit financing example, this time in conjunction with electronic mail. The corresponding redesign alternative (number 3) is labeled "e-document infrastructure" to denote the non-paper-based nature of the proposed process change. The fourth redesign alternative, "contracts workflow system," is generated from a similar but more-sophisticated transformation to automate "routine workflows" (see Georgakopoulos et al. 1995) associated with contracts work. This latter measurement-driven redesign recommendation is driven by the same pathologies noted above, with the addition of "labor-intensive process" (i.e., negligible IT automation). The reader may notice this workflow redesign reflects exactly the kind of technology embedded within the DoD Standard Procurement System (SPS). Thus, the results stemming from redesign of this J&A process may also have implications for processes supported by SPS.

Continuing down the table entries, we find the same case manager transformation (i.e., from the credit financing example) matched consistently with the job specialization and process friction pathologies. This redesign transformation is used to generate a "J&A case team" redesign, which envisions an integrated team (e.g., including the CS, KO, RACA, PACA and legal representative) working together through the entire J&A process. The job specialization pathology also matches with three empowerment transformations—two oriented toward expanding CS responsibilities and one that includes enlarging the KO job scope. Basically, these eight redesign alternatives result from the same application of diagnostic measures, knowledge taxonomies and rule-based inference that are described in terms of the credit financing example, except they are applied here in the field to an operational J&A process from the military procurement domain. We now elaborate further on the redesign results.

Redesign Results

We noted above that simulation is used to assess the relative performance of redesign alternatives. To help reduce the number of simulation models required, we enlist the support of process experts to refine the set of redesign alternatives generated above. Combining their in-depth process knowledge with evaluation criteria such as process feasibility, implementability and projected benefit, this team identifies a subset of the redesign alternatives from above as "preferred" (emphasized by bold print in Table 13). For example, the experts predict the joint reviews alternative (number 2) will produce greater benefit than its concurrent-reviews counterpart (number 1). They express a similar preference for the contracts workflow system (number 4) over its e-document counterpart (number 3). The experts also assess these first four redesign

alternatives to be both feasible and implementable in the current organization (Project Reviews 1995).

Table 13 Redesign Alternatives

Diagnosed Pathology	Recommended Transformation	Redesign Alternative
Sequential process flows + review-intensive process	De-linearize (approvals)	1. Concurrent reviews
Sequential process flows + review-intensive process	De-linearize (approvals)	2. Joint reviews
Manual process + paper-based process + process friction	Shared database + e-mail	3. E-document infrastructure
Manual process + paper-based process + process friction + labor-intensive process	Workflow management system	4. Contracts workflow system
Job specialization + process friction	Case manager	5. J&A case team
Job specialization	Empowerment (3)	6-8. CS and KO job enlargement

bold denotes "preferred" redesign alternative

In contrast, although the experts can foresee good potential for the case manager and empowerment alternatives (numbers 5-8), and they similarly view them as feasible transformations, their judgment is the required organizational changes are not implementable at the present time. As a result of the expert analysis, we simulate only the two, preferred redesign alternatives (i.e., the subset selected by the experts). This approach is actually recommended by the process managers as a way to expedite the analysis, and it may represent a prudent use of analytical resources in other reengineering engagements as well.

For this analysis, the *simulated* cost and cycle time of each redesign alternative is compared with that of the J&A process baseline. The baseline J&A simulation model is first validated using recent performance data (e.g., process cost, cycle time, throughput), reviewed by process experts and subjected to other validation techniques. For example, construction of the simulation model itself is homomorphic (see Roberts 1979) to the baseline measurement-driven redesign process model; that is, each of the same agents, tasks and resources used to represent the baseline J&A process diagrammed above is also used in the dynamic simulation model.

A commercial software package (WITNESS) is employed to simulate the performance of the J&A baseline and each "preferred" redesign alternative. In this analysis, activity-based cost and cycle time are used to measure process performance. Other measures such as throughput, rework, agent-utilization and the like are also informative, but cost and cycle time are the output measures of interest here. This is consistent with a similar emphasis on cost and cycle time found in the reengineering literature. To compare the relative

performance of the redesign alternatives, each simulated process is run for the equivalent of one, steady-state fiscal year; that is, the dynamic model is allowed to "warm up" and stabilize before simulated performance for the fiscal year is measured.

Table 14 Redesign Simulation Results

Redesign Alternative	Cost Reduction	Cycle Time Reduction
Joint Reviews	28%	67%*
Contracts Workflow System	nil	67%*

* denotes performance-doubling

Simulation results for the J&A process are summarized in Table 14 for reference. From the table entries, we see the joint-reviews transformation results in a 28% (simulated) cost improvement over the baseline, primarily due to a reduction in rework enabled by the joint-meeting format. More impressive, this redesign alternative results in a two-thirds reduction in cycle time for performance of the J&A process. The reduction in rework contributes in part to this result, but the decreased cycle time is driven primarily by concurrent review (i.e., parallel vs. sequential performance). The asterisks in the table are used to denote results that exceed the performance-doubling threshold established for the field study. This threshold is intended to differentiate between "dramatic" performance improvements (i.e., as sought through BPR) and "incremental" gains (i.e., reflecting more of a TQM approach).

Interestingly (and coincidentally), the contracts workflow system matches this two-thirds reduction in cycle time, but it produces negligible savings in terms of cost. The reduced friction associated with eliminating J&A paper handoffs (e.g., work sitting in in-boxes and out-boxes, awaiting assignment, pausing for review and approval) contributes toward this dramatic cycle-time improvement, as does the decreased transportation time between process activities. The absence of cost savings is attributable to the fact that the process *tasks* themselves remain fundamentally unchanged with the workflow system; that is, the J&A work itself remains the same, as only the interface and communication between activities are automated through the workflow management system. We noted above this effect has been colorfully referred to as "paving the cowpaths" in the reengineering literature (Hammer 1990).

It is also important to note these two redesign alternatives are generated *independently*. The analysis recommends each transformation be applied to redesign the J&A process individually. However, this does not prohibit applying them in combination. Indeed, a manager can elect to combine these two (or any other) transformations and attempt to produce even more dramatic gains in performance. However, each such combination requires a separate simulation, for the individual results (esp. cycle time) are unlikely to be additive.

CHAPTER 3 SUMMARY

Drawing from the BPR FAQs, nearly all large U.S. corporations have engaged in major reengineering projects, and the Government, including many military commands, is also deeply involved in reengineering today. The term *reengineering* itself has been defined as, the *fundamental* rethinking and *radical* redesign of business *processes* to achieve *dramatic* improvements in critical, contemporary *measures* such as cost, quality, service, and speed. Probably the most distinguishing feature between BPR and TQM is a matter of degree. The emphasis of the former is on singular and dramatic performance improvement through radical process redesign, whereas more continuous and incremental gains are generally expected through the latter. The primary reason most firms reengineer is either to keep up with performance improvements effected at rival firms or to attain competitive advantages of their own. Reengineering methodologies differ with respect to analysis of an existing process baseline configuration and in many other ways. But of the methodologies that stress baseline process analysis, measurement is assigned a very important role. Finally, although IT is heralded as the central enabling technology for reengineering, the experts caution against the sole or excessive reliance on this transformation technology, and other enablers of process innovation such as human and organizational interventions are adduced.

Process innovation is modeled as a spiral process comprised of eight steps: 1) identify a target process for redesign; 2) construct a baseline process model; 3) obtain configuration measurements; 4) diagnose process pathologies; 5) match appropriate redesign transformations; 6) generate redesign alternatives; 7) test through simulation; and 8) select a preferred alternative for implementation. These steps are included in the measurement-driven redesign approach used above to redesign a commercial process from the literature and a procurement process in the field. This represents a systematic approach to process redesign, which is capable of matching the performance of BPR consultants—as in the credit financing case—and effecting dramatic cost and cycle-time performance improvements in procurement processes—as with the J&A process.

CHAPTER 3 QUESTIONS

1. In what respects does business process reengineering differ from total quality management?
2. What has been considered the most powerful technology available to enable process innovation?
3. Through which techniques is reengineering knowledge captured for use through measurement-driven redesign?

CHAPTER 3 ANSWERS

1. Despite differences in terms of scale, scope and risk, BPR and TQM vary predominately in degree and represent both compatible and complementary endeavors.
2. Information technology is widely regarded as the most powerful enabler of radical process redesign and dramatic performance improvement.
3. Primary techniques for reengineering knowledge capture include the use of measurements, taxonomies—one for process pathologies, another for redesign transformations—and rules.

Chapter 4 - Contracting Innovation

In this final chapter, we integrate the concepts and techniques presented above to innovate the contracting process. Indeed, employing the process innovation approach from above, we further innovate a contracting process that has already been substantially improved through alpha contracting. Drawing from our discussion above, this example pertains to the JSOW alpha contracting process. The JSOW example is used not only to explain and demonstrate the application of process innovation techniques from above, but to also develop a process vision for future contracting innovations. To begin this discussion, first we draw again from Nissen (1998a) to briefly describe the alpha contracting process and delineate its workflow. Then we apply redesign techniques to further innovate the process and assess strengths and weaknesses of each process redesign alternative. The chapter concludes with a summary.

ALPHA CONTRACTING INNOVATION EXAMPLE

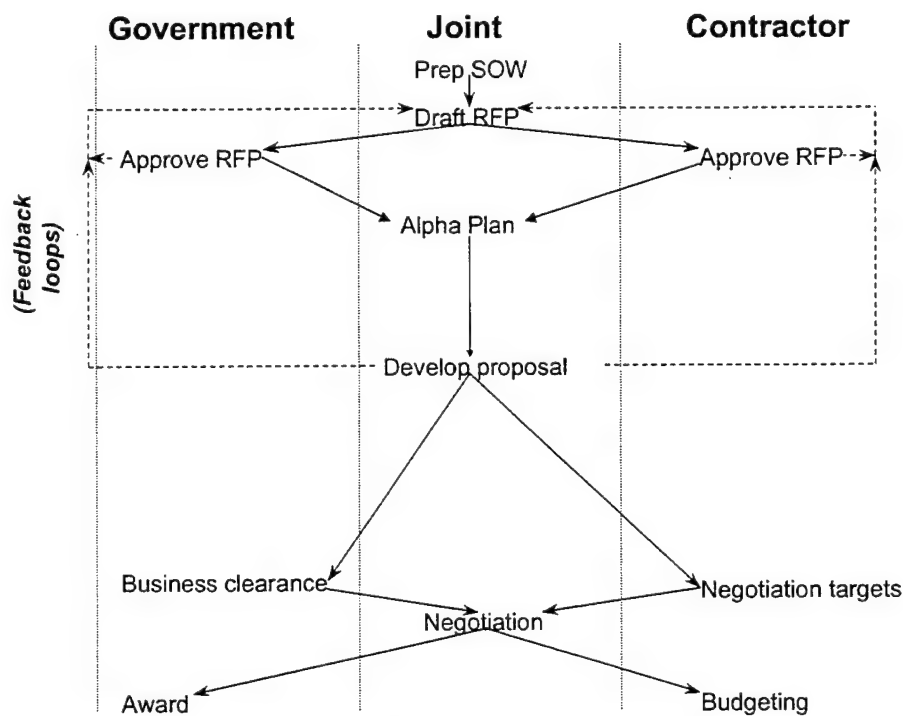


Figure 9 JSOW Alpha Contracting Process Flow

The JSOW program described above represents a major (e.g., ACAT ID) weapon system. Although we noted above the techniques and benefits of alpha contracting are in no way limited to such large, complex procurements, examination of this major contracting case highlights many additional considerations that

benefit the present discussion. The JSOW process is also useful to demonstrate how further innovation is possible with an alpha contracting process.

For reference, the JSOW alpha contracting process flow is delineated in Figure 9. Notice this process flow bears a very close resemblance to the general alpha contracting flow presented in Figure 2.

For clarity, and because the JSOW program operates strictly within a sole-source environment, we omit the process steps pertaining to synopsis by the Government and expression of interest by the contractor. But notice an additional step for alpha planning that precedes the "develop proposal" activity. To help organize and streamline the alpha contracting process, the JSOW team divides the SOW/RFP into areas of responsibility and cost accounts that are assigned to specific individuals, from both sides of the contract, for development. For example, the SOW/RFP associated with the air vehicle may be assigned to the program managers' deputies (i.e., for both the Government and contractor teams) to manage in total. Further, each major cost account associated with the air vehicle (e.g., engineering, manufacturing, logistics, materiel) is assigned to lead individuals, from both sides, to develop. With this, we generally have engineering cost account managers working together on the engineering proposal estimates, manufacturing cost account managers working together on the manufacturing proposal estimates, and so forth.

Baseline Process Model

Using the notation introduced in Chapter 3, the JSOW alpha contracting process is modeled for redesign analysis in Figure 10. As in Figure 9 above, the process begins with SOW preparation (activity node labeled "A" for reference), but for clarity, the flow depicted in Figure 10 stops with the negotiation step (activity node labeled "G" for reference). The attributes listed beneath each activity node indicate the following four properties: 1) name (e.g., SOW development) of the process activity, 2) role (e.g., technical work) and organization (e.g., contractor) responsible for performance of the activity, 3) tools (e.g., word processor) used to support the activity, and 4) media (e.g., paper documents) used for communication and flow of work between activities. A fifth attribute for automation (e.g., through IT) is also included, but the alpha contracting process involves no such automation in its present state. Continuing with the first, SOW preparation activity (labeled "A"), it principally involves technical work (denoted by the label "T"), and one can observe both the Government and contractor (labeled "G & C") jointly perform this task using a word processor (labeled "WP") for support. Communications are effected using two media: paper for documentation and meetings for joint discussion. The same basic attributes can also be observed for the subsequent draft-RFP (node "B"), alpha-planning (node "C") and proposal-development steps (node "D").

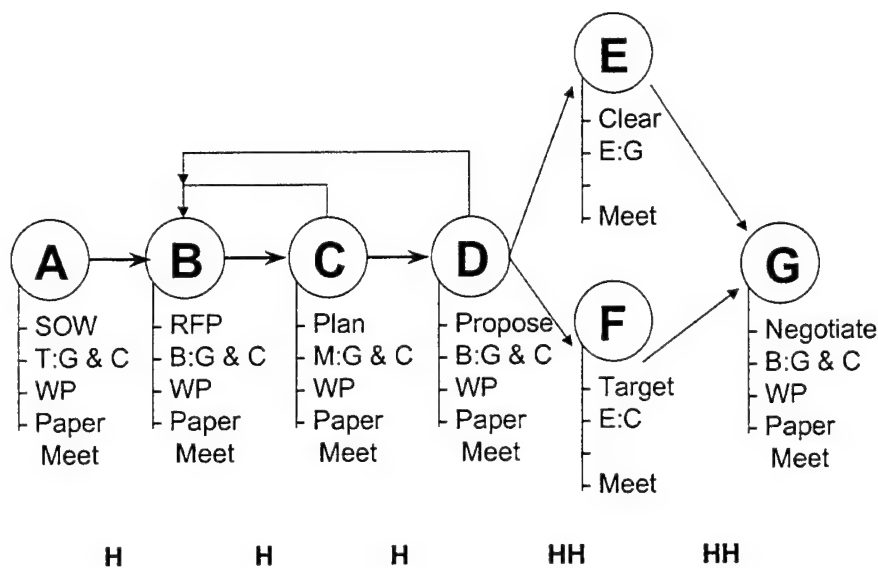


Figure 10 JSOW Alpha Contracting Process Model

Notice two feedback loops flowing back to the draft-RFP activity (node "B"). The first one, stemming from node "C," reflects the fact that a draft RFP may not be approved when reviewed by the Government and contractor teams (see Figure 9), in which case the draft RFP is remanded to the alpha contracting IPTs for rework. The second one, stemming from node "D," similarly reflects the fact that a draft proposal may not be approved when reviewed by the respective teams noted in Figure 9, and hence may likewise be remanded to the alpha contracting IPTs for rework. Although not shown in the figure to avoid cluttering the diagram, clearly, such feedback loops can also extend back to the SOW preparation activity. For instance, oftentimes, technical scope must be reduced for a program to fit within budget constraints.

As delineated above, the process flow splits after node "D," as the Government and contractor organizations separately develop their business clearances and establish negotiation targets, respectively. Little in the way of support tools is used to support these steps, as they consist principally of face-to-face meetings with the respective management groups (e.g., through presentations). The process flow converges again through the negotiation activity (node "G"), which is performed jointly by the Government and contractor. As with some preceding activities, paper is used to document the final negotiation results, and bargaining is generally conducted in a face-to-face manner.

Finally, the bold-face letter "H" is used to designate handoffs in the process, as work is passed from people in one organizational role to another. For instance, the first such handoff occurs between the

SOW-preparation (node "A") and draft-RFP (node "B") activities. This handoff reflects the fact that SOWs are generally developed by technical people (e.g., design engineers, manufacturing engineers, logistics engineers; denoted by the label "T"), whereas RFPs receive the greater attention from business people (e.g., contract specialists, price/cost analysts, estimators; denoted by the label "B"). Thus, we mark a handoff from one organizational role to another. A similar handoff occurs between the next activities (i.e., nodes "B" and "C"), as the business people responsible for drafting the RFP are generally much lower in the organizational hierarchies than the managers who develop the alpha contracting plan (e.g., program managers and deputies; denoted by the label "M"). Thus, we mark another handoff from one organizational role to another. Indeed, the model in Figure 10 depicts one such handoff at every step of the process flow. It is important to note, however, that this *alpha contracting* process involves substantially fewer such handoffs than its baseline counterpart that we noted above as the "traditional" (i.e., pre-alpha) contracting process.

Process Measurement and Diagnosis

Process measurements and diagnoses obtained from the JSOW model represented in Figure 10 are summarized in Table 15. Starting at the top, the first measurement (7) for process size indicates the seven activities (i.e., A through G) for the process. The feedback fraction measurement (0.29) is calculated as the ratio of feedback loops (2) divided by process size (7) and represents a relatively good value for the contracting process. Before the alpha contracting innovation, for instance, the feedback fraction would easily be double this measured value. This quantifies some of the considerable progress made by the alpha contracting innovation over the "traditional" contracting process baseline. The next measurement for parallelism (1.17) reveals the process remains quite sequential, however. But as with the feedback measurement, this degree of parallelism reflects considerable improvement (17%) over the baseline process. Thus, we see even the alpha contracting process still suffers from sequential process flows, which has cycle time implications.

Continuing down the table, the IT-Support fraction (0.71) reveals relatively good usage of IT in the process, as five of the seven activities involve use of a word processor ("WP"). That is not to say additional IT could not be employed, but the process is clearly not deficient in this regard. In contrast, the measured values of IT-Communication (0.00) and IT-Automation (0.00) reflect theoretical minima for the corresponding metrics. This quantifies the fact that IT is not employed for communication and none of the process steps is automated. Thus, the process suffers potentially serious pathologies in terms of being paper-based and labor-intensive, which have both cost and cycle time implications. Finally, the measured handoffs fraction (1.00) indicates each of the seven process steps is accompanied by a handoff between people performing different organizational roles. Such handoffs are associated with the pathology of process friction, which can have severe implications in terms of cycle time. Thus, even with the streamlining

enabled through the alpha contracting innovation, the JSOW contracting process still suffers from a number of serious pathologies. Therefore it follows that even the alpha contracting process offers potential for further innovation.

Table 15 JSOW Baseline Configuration Measurements and Diagnoses

Configuration Measure	Value	Diagnosis
Process Size	7	
Feedback fraction	0.29	
Parallelism	1.17	Sequential process flows
IT-Support fraction	0.71	
IT-Communication fraction	0.00*	Paper-based process
IT-Automation fraction	0.00*	Labor-intensive process
Handoffs fraction	1.00	Process friction

* denotes theoretical extremum for a measure

Process Redesign

Based on the process measurements above, a number of redesign transformations can be identified to further enhance the JSOW alpha contracting process. In this section, we explicitly examine three classes of redesigns: 1) de-linearization, 2) IT and 3) frictionless. It is important to note these classes are not mutually exclusive; that is, one can combine de-linearization with IT and frictionless redesigns. Here, we present them separately for clarity and leave such combination as a practical exercise for the reader in his or her own organization.

De-linearization redesign. Looking first at the parallelism measurement, we ask whether any of the process activities could be performed concurrently. The usual technique for making this assessment is to determine whether inputs and outputs are mutually exclusive; that is, one looks at the inputs to a particular process and makes a determination whether outputs from the predecessors are required for its performance. If so, the activities must be performed in series. But if not, this presents an opportunity to perform them in parallel (i.e., de-linearize). For instance, output from the first process activity—SOW-preparation in node "A"—generally includes a statement of work. So one asks whether the SOW is required for the next activity—draft-RFP in node "B." In some respects, the answer is yes, in that a completed RFP specifies the work to be performed.

But one could argue a substantial amount of RFP work (e.g., selecting contract type, identifying clauses for incorporation, drafting inspection, acceptance, packaging and other requirements) could at least begin while the SOW was being developed. In other words, many aspects of RFP preparation do not depend on the SOW. Thus, we may be able to increase alpha contracting process parallelism by at least *starting* the draft-RFP process activity before the SOW has been completed, possibly deferring integration of the two

until the planning step (node "C"). Though again, clearly, the RFP activities cannot be completed without having the procurement requirements (i.e., the SOW).

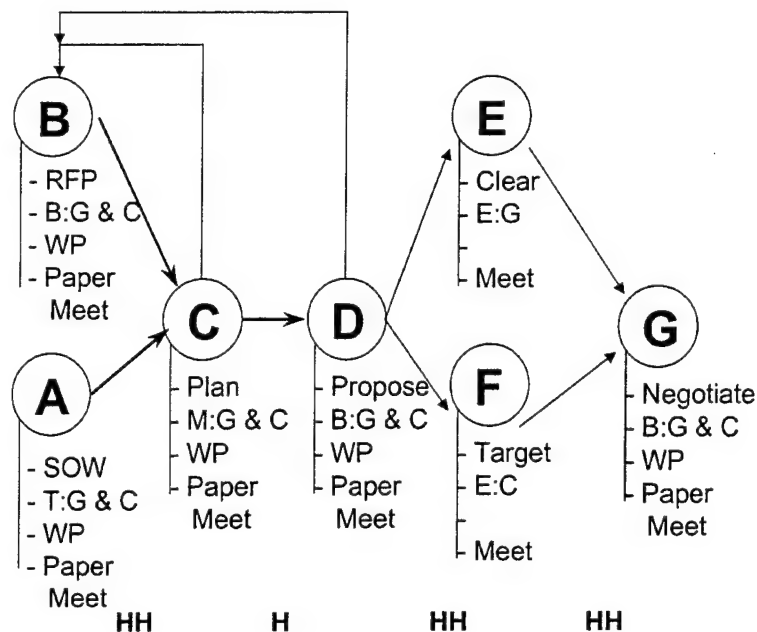


Figure 11 JSOW De-linearization Process Model

Table 16 JSOW Comparative Process Measurements

Configuration Measure	Baseline Value	Redesign Value
Process Size	7	7
Feedback fraction	0.29	0.29
Parallelism	1.17	1.40
IT-Support fraction	0.71	0.71
IT-Communication fraction	0.00*	0.00*
IT-Automation fraction	0.00*	0.00*
Handoffs fraction	1.00	1.00

* denotes theoretical extremum for a measure

This partial process redesign is delineated in Figure 11 with corresponding measurements summarized in Table 16 for comparison with the baseline alpha contracting process. Notice process length would decrease to 5 in this de-linearized redesign. This effect can be observed in the figure through parallel performance of nodes "A" and "B" and is quantified by the parallelism measurement, the latter of which increases to 1.40 through the redesign. Shortening process length in this fashion should have a direct impact on decreasing process cycle time. Similar analysis of other process activities may reveal additional opportunities to increase process concurrency through partial de-linearization. Again, the customary technique involves examining inputs to and outputs from successive process activities to determine whether

serial activities are sequentially dependent (i.e., must be performed serially) or not (i.e., can be performed concurrently).

IT redesigns. The IT-oriented pathologies can also be addressed through process redesign, particularly paper-based process communications. Since process documents are prepared using a word processor now, there is little reason why they cannot be transmitted via computer (e.g., as e-mail attachments) between the various steps of the process. Even if paper copies are printed *within* each process activity (e.g., used by the alpha contracting teams), cycle time may be reduced through electronic transmission *between* process activities (e.g., SOW preparation and draft RFP). But this raises the issue of control. One positive aspect of paper-based communication is that copying one original document helps ensure every recipient receives the same information.

Alternatively, without control over electronic document transmission, an engineer, say, could modify the SOW and send it to his or her technical counterpart without notifying the contracts and pricing people. Similarly, a program manager could change one of the scheduling assumptions without notifying the engineers. Many similar examples can be developed. Notwithstanding available control techniques, such as issuing written policy statements against unauthorized changes and using change-tracking features of modern word processors, document control remains an important consideration whenever electronic communications are envisioned.

One approach is to centralize electronic distribution, and the Web enables such centralization without compromising decentralized document production (e.g., by each alpha contracting team member). Through such an approach, each team member could generate documents and make changes as in the process above, but such documents and changes would only be disseminated from a single Web server. As in a technical configuration management environment, for example, individual engineers, program managers or contracting professionals could be required to "check-out" each document from a central repository on the Web server. While changes are being made by this individual, the checked-out document would have read-only access to other individuals until the changes are complete. And here is where change tracking could be used most effectively to ensure accountability for changes to a document. This redesign can effect electronic communication between every process activity, which offers excellent potential for reducing cycle time and complements the existing use of IT (e.g., word processors) in the process. Indeed, the Web is used for contracting activities such as market research today, so the necessary infrastructure and experience is likely to already be in place in many contracting offices.

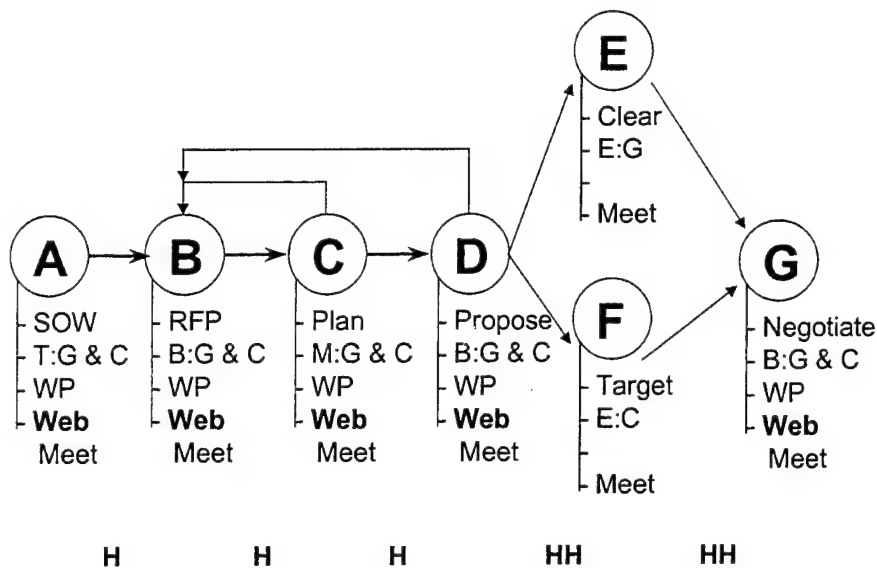


Figure 12 JSOW Web-centric Process Model

This Web-centric means of enabling redesign through electronic communication is delineated in Figure 12 with corresponding measurements summarized in Table 17 for comparison with the baseline alpha contracting process. Notice IT-Communication fraction would increase to 0.71 in this Web-enabled redesign. This represents dramatic improvement over the process baseline, the measurement for which (0.00) represents negligible electronic communication and a theoretical minimum for this measure. This effect can be observed in the figure through the "Web" attributes associated with communications. Implementing electronic communications in this fashion should have a direct impact on decreasing process cycle time. Similar analysis of other process activities may reveal additional opportunities to increase electronic communication through complementary technologies.

Table 17 JSOW Comparative Process Measurements

Configuration Measure	Baseline Value	Redesign Value
Process Size	7	7
Feedback fraction	0.29	0.29
Parallelism	1.17	1.17
IT-Support fraction	0.71	0.71
IT-Communication fraction	0.00*	0.71
IT-Automation fraction	0.00*	0.00*
Handoffs fraction	1.00	1.00

* denotes theoretical extremum for a measure

Regarding the negligible IT-Automation, this pathology is more difficult to address than its IT-Communication counterpart above, for much of the required information technology has yet to emerge from the research laboratory. Notwithstanding a number of legacy systems (e.g., APADE, SACCONS) that offer some automated support for contractual documentation, such systems automate only the most basic aspect of document composition, and many feel they inhibit the process as much as they facilitate it (e.g., see McCarthy 1998, Nissen 1996b). Even the Standard Procurement System (SPS), which represents a marked improvement through workflow functionality and EDI interface, automates only the most routine and perfunctory aspects of procurement (e.g., clause selection, document composition, forms routing). Indeed, if we define automation as the performance of work activities *without a person* in the loop, it is more accurate to describe SPS in terms of IT-Support than IT-Automation, for it automates very little. Still, implementation of SPS in the JSOW alpha contracting process would serve to further streamline and enhance it. And given plans for DoD-wide SPS implementation, it is only a matter of time before the JSOW process is streamlined in this manner.

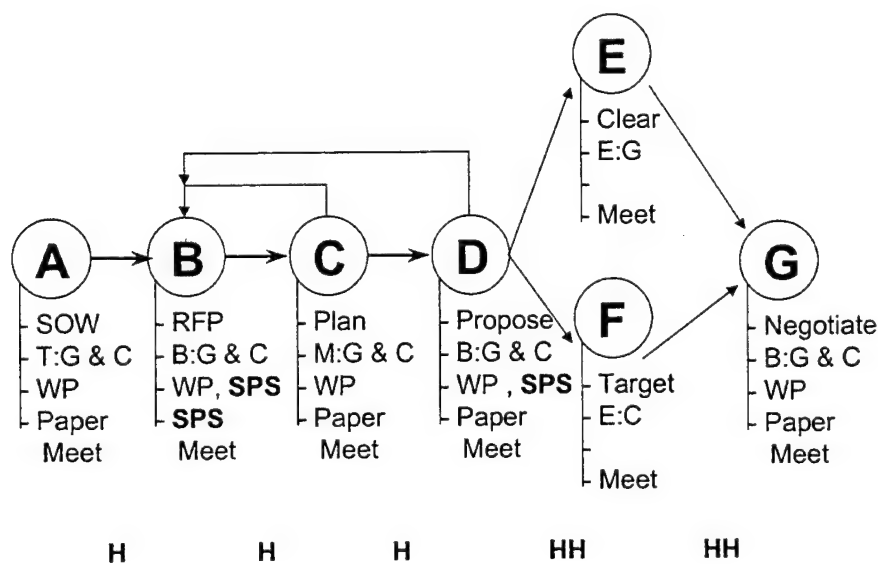


Figure 13 JSOW SPS Process Model

This SPS-based redesign is delineated in Figure 13 with corresponding measurements summarized in Table 18 for comparison with the baseline alpha contracting process. Notice IT-Support fraction would increase to 1.00 in this SPS-based redesign. This represents modest improvement over the process baseline. This effect can be observed in the figure through the "SPS" attribute associated with the draft-RFP and

proposal activities (nodes "B" and "D"). As SPS capabilities expand to support more of the contracting process life cycle, opportunities to further improve the IT-Support fraction may present themselves. Notice SPS also supports electronic communication of the draft-RFP activity (node B) and increases the IT-Communication measurement slightly (0.14).

Table 18 JSOW Comparative Process Measurements

Configuration Measure	Baseline Value	Redesign Value
Process Size	7	7
Feedback fraction	0.29	0.29
Parallelism	1.17	1.17
IT-Support fraction	0.71	1.00
IT-Communication fraction	0.00*	0.14
IT-Automation fraction	0.00*	0.00*
Handoffs fraction	1.00	1.00

* denotes theoretical extremum for a measure

Alternatively, some very promising information technology is beginning to emerge from the research laboratory (e.g., see Nissen 1997) to automate a number of important, time-consuming procurement activities. One class involves the use of knowledge-based systems (KBS) to perform key contracting activities such as RFP composition, contracting-officer review, proposal analysis and others. Building on expert systems expertise, such tools offer potential to eliminate a number of human steps from the contracting process, which has positive performance implications both in terms of cost and cycle time. In fact, contracting KBS have now emerged from the laboratory (e.g., CESA: Contracting officer's technical representative Expert System Aid; see Liebowitz 1999).

Although such systems are unlikely to ever replace all the people in the process, the possibility of having some 80% of tasks performed automatically (e.g., using an "80/20" rule) is exciting. For instance, a KBS could be used to process some 80% or so of contracting tasks that are routine and perfunctory (e.g., mandatory clause selection). With this, contracting professionals (i.e., people) could then be freed to use their expertise for more novel, complex and demanding issues and problems. And if such technology can be effectively integrated with the Web and workflow systems such as SPS, the performance implications are huge. As noted recently, this technology represents the next generation of capability for SPS (see Karty and Nissen 1999).

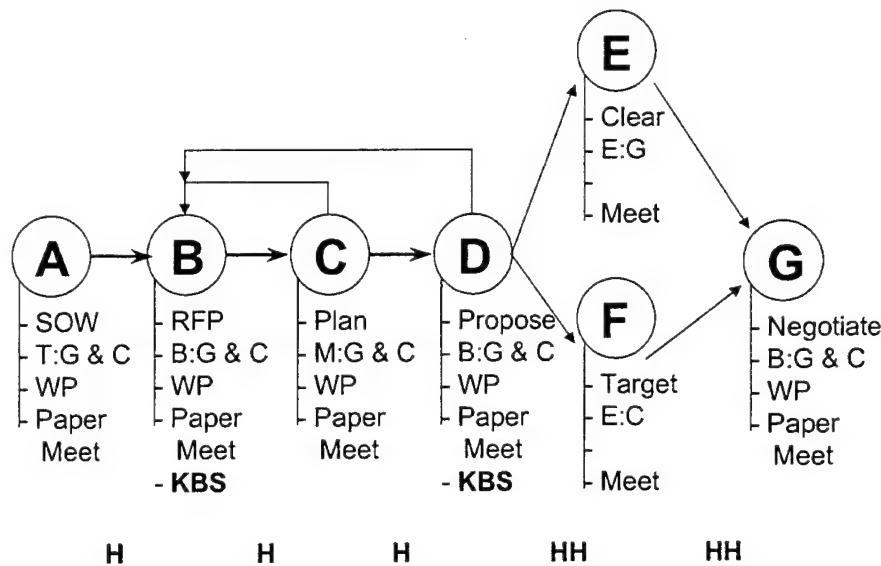


Figure 14 JSOW KBS Process Model

This KBS-based redesign is delineated in Figure 14 with corresponding measurements summarized in Table 19 for comparison with the baseline alpha contracting process. Notice IT-Automation fraction would increase to 0.29 in this KBS-enabled redesign. This represents dramatic improvement over the process baseline, the measurement for which (0.00) represents negligible process automation and a theoretical minimum for this measure. This effect can be observed in the figure through the "KBS" attributes associated with automation. Automating activities in this fashion should have a direct impact on decreasing both process cost and cycle time. However, much greater leverage could be achieved through this redesign when it is integrated with other IT-based transformations. As noted above, this leverage is particularly great through integration with Web communications and SPS.

Table 19 JSOW Comparative Process Measurements

Configuration Measure	Baseline Value	Redesign Value
Process Size	7	7
Feedback fraction	0.29	0.29
Parallelism	1.17	1.17
IT-Support fraction	0.71	0.71
IT-Communication fraction	0.00*	0.00*
IT-Automation fraction	0.00*	0.29
Handoffs fraction	1.00	1.00

* denotes theoretical extremum for a measure

Another, more advanced class of promising information technology beginning to emerge from the research laboratory (e.g., see Nissen 1999) involves the use of intelligent agents to represent buyers and sellers in transactions. Also involving artificial intelligence, intelligent agents have been developed to capture enterprise work rules and user preferences to automatically perform a number of procurement activities (e.g., market research, RFP preparation and transmission, proposal preparation and transmission, proposal analysis and source selection, ordering, payment) without human intervention. In a nutshell, agents representing the Government program office and contractor can perform most of the baseline alpha contracting process activities delineated in Figures 9 and 10 on behalf of their principals. This has enormous performance implications in terms of cost and cycle time. But more so than above, such systems are unlikely to ever replace all the people in the process, and intelligent agent technology is less mature than its KBS counterpart above. Thus, it is not yet ready for emergence from the laboratory. Nonetheless, as noted recently, this technology represents the generation after next of capability for SPS (see Karty and Nissen 1999).

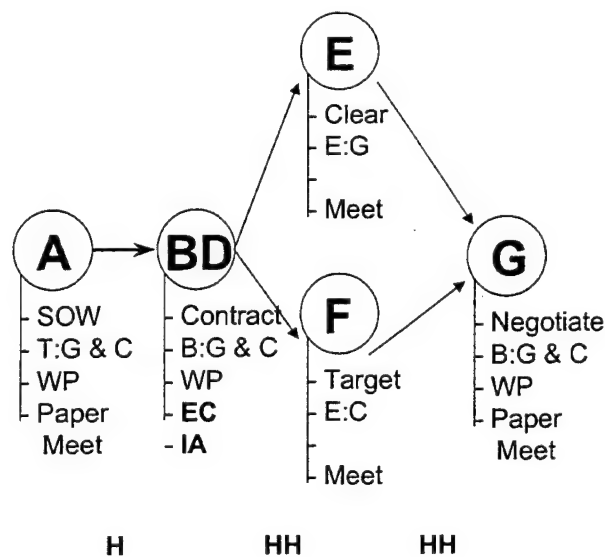


Figure 15 JSOW Agent Process Model

This agent-based redesign is delineated in Figure 15 with corresponding measurements summarized in Table 20 for comparison with the baseline alpha contracting process. For conservatism, we continue to include activities for the business clearances (node "E") and negotiation targets (node "F"), and we do not show the agents conducting negotiations (node "G"). Notwithstanding progress being made with

respect to agent-based negotiation, particularly for large contracts such as the JSOW, agents are unlikely to conduct negotiations in the near future. If not for these conservative assumptions, the process depicted in Figure 15 would have only two steps: SOW-preparation (node "A") and one consolidated activity reflecting agent-based tasks.

Returning to the more-conservative process redesign delineated in Figure 15, notice a number of process changes. First, process size drops to 5 activities from 7. This reflects agent consolidation of activities that were performed separately by people (i.e., "B" and "D"). Parallelism also increases slightly, due to this consolidation. And the agent approach obviates the feedback loops, bringing the feedback fraction effectively to zero. All three of the IT fractions are affected through this dramatic change, with IT-Communication and IT-Automation both showing marked gains.

Table 20 JSOW Comparative Process Measurements

Configuration Measure	Baseline Value	Redesign Value
Process Size	7	5
Feedback fraction	0.29	0.00*
Parallelism	1.17	1.20
IT-Support fraction	0.71	0.60
IT-Communication fraction	0.00*	0.20
IT-Automation fraction	0.00*	0.20
Handoffs fraction	1.00	1.00

* denotes theoretical extremum for a measure

This represents dramatic improvement over the process baseline, the measurements for which (0.00) represent negligible electronic communication or process automation and theoretical minima for these measures. These effects can be observed in the figure through the "EC" and "IA" attributes associated with agent-based communication and automation, respectively. Automating activities in this fashion should have a direct impact on decreasing both process cost and cycle time. However, as with the KBS redesign noted above, much greater leverage could be achieved through this agent redesign when it is integrated with other IT-based transformations. This leverage is particularly great through integration with Web communications and SPS.

Frictionless redesigns. The final alpha contracting pathology to be addressed is the substantial friction stemming from numerous handoffs in the process. From above, handoffs derive from work passing between people performing different roles in the process flow. A widely used approach to reducing handoffs in a process is to enlarge the job breadth of process participants. The most extreme example of this is through a case manager, in which a *single* individual performs all process steps. This is probably unrealistic in the case of procurement and contracting, but even two organizational roles that can be spanned through job enlargement leads to a corresponding reduction in process friction, with its attendant cycle time

implications. Thus, we would examine each of the process activities to assess whether it could be performed without use of a specialist. For instance, the first two process activities—SOW-preparation and draft-RFP—are currently performed by people with different organizational roles: technical people and business workers. We would ask whether people from one role or the other could perform both activities; that is, could engineers and other technical people perform the business tasks associated with RFP preparation, or could contract specialists and other business people perform the technical tasks associated with SOW development? In light of current technology available to support the process, and the considerable education, training and experience required for technical and business people to become proficient in their respective areas of expertise, this is unlikely to be feasible at present.

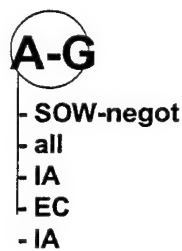


Figure 16 JSOW Frictionless Process Model

However, the knowledge systems and intelligent agents discussed above may offer potential in this regard. For example, a knowledge system capable of composing simple RFPs could be employed by the *technical people* to perform this activity. This is far more likely and promising than trying to invent some technology that would enable contracts people to prepare statements of work. And as noted above, such systems are now out of the research laboratory and may represent the next generation of capability for SPS. Even more impressive are the intelligent agents. With suitably-developed technology, these same technical people could employ agents to perform *all the activities* required for contracting in a relatively simple procurement. Although this is unlikely for a large, complex procurement such as the JSOW, the promise of agent technology for the huge volume of simplified procurements is gargantuan. And as noted above, such

systems are now being demonstrated in the research laboratory and may represent the generation after next of capability for SPS.

Table 21 JSOW Comparative Process Measurements

Configuration Measure	Baseline Value	Redesign Value
Process Size	7	1
Feedback fraction	0.29	0.00*
Parallelism	1.17	1.00
IT-Support fraction	0.71	1.00
IT-Communication fraction	0.00*	1.00
IT-Automation fraction	0.00*	1.00
Handoffs fraction	1.00	0.00*

* denotes theoretical extremum for a measure

This frictionless redesign is delineated in Figure 16 with corresponding measurements summarized in Table 21 for comparison with the baseline alpha contracting process. Here, we show intelligent agents performing all the procurement steps from SOW-preparation (formerly node "A") through negotiation (formerly node "G"). Notice the dramatic effect on all process measures. Although this process redesign is obviously very extreme and futuristic, it is informative to view such a redesign in terms of a vision for the procurement process of the future.

Metaphorically speaking, if man never dreamed about flying, he probably would never have set about to build airplanes. If we never develop future process visions, researchers are unlikely to pursue the technologies required to bring them about. Moreover, futuristic as this process vision may appear at first, many of the requisite technologies (e.g., Web communications, knowledge-based systems, intelligent agents) are available *today*. But until the contracting organization is ready for such technologies—that is, ready to pursue such a radical process vision—such technological innovation is unlikely to become manifest in contracting practice.

CHAPTER 4 SUMMARY

The JSOW process is useful to demonstrate how further innovation is possible with an alpha contracting process. Using the notation and redesign approach introduced in Chapter 3, the JSOW alpha contracting process is modeled for redesign analysis, measured to diagnose pathologies and redesigned to further improve performance. Measurements reveal a number of serious pathologies, even with the innovative, alpha contracting process used as a baseline for analysis. These pathologies include sequential process flows and a paper-based, labor intensive process with considerable friction. Together, such process pathologies have adverse implications in terms of both cost and cycle time.

Three classes of redesigns are examined: 1) de-linearize, 2) IT and 3) frictionless. We examine and discuss each redesign individually. But it is important to note the redesigns are in no way mutually exclusive, and even greater performance improvements may be possible by combining them. The de-linearize redesign is applied through performance of two or more process activities in parallel, as opposed to serially. To demonstrate the technique, we depict partial performance of two parallel activities—SOW preparation and draft RFP—in this fashion. De-linearization offers good potential in terms of cycle time reduction.

Four IT-driven redesigns are examined above. The first two redesigns—Web-based communications and SPS implementation—are enabled through information technology that is readily available today. The use of Web-based, electronic communications is particularly noteworthy for enabling cycle time reduction without sacrificing control over contractual documents. The second two redesigns—through knowledge-based systems and intelligent agents—are based on information technologies that remain closer to the laboratory than the operational contracting office. But they offer enormous potential in terms of dramatic cost and cycle time reduction.

The frictionless redesign involves elimination of handoffs between process activities and requires IT support. We examine the use of intelligent agent technology to collapse the entire procurement process into a single, automated activity. Although very radical, this frictionless process redesign serves to present a vision of the future of procurement. Such a vision is important to guide research and represents a goal toward which contract managers should strive. But despite this focus on the future, the technology required to enable the corresponding process vision is less than a half decade away at the time of this writing.

CHAPTER 4 QUESTIONS

1. Which process pathologies affect even the innovative, alpha contracting process?
2. What are the performance implications of these pathologies?
3. Which information technologies offer potential for performance improvement through process redesign?
4. Which non-IT transformations offer potential for performance improvement through process redesign?

CHAPTER 4 ANSWERS

1. Alpha contracting process pathologies include sequential process flows and a paper-based, labor intensive process with considerable friction.
2. Together, such process pathologies have adverse implications in terms of both cost and cycle time.
3. Web-based electronic communications, the Standard Procurement System, knowledge-based systems and intelligent agents represent information technologies with good potential for process performance through redesign.
4. Process de-linearization and frictionless redesigns do not necessarily require IT for performance improvement. However, in the example above, frictionless redesign is seen to benefit from IT support.

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¹ It is important for the experienced reader to note the intent here is to capture the *key*, high-level activities and sequencing associated with the contracting process in general. Notice too that many process steps (e.g., DCAA audit, Independent Government Analysis, etc.) have purposefully been omitted from the diagram to reduce clutter and focus the discussion. The point is to abstract away from the myriad details that do not contribute to comparison.

¹ See Rummier, G. and Brache, A. *Improving Performance: How to Manage the White Space on the Organization Chart*. San Francisco, CA: Jossey-Bass (1991).

¹ See Arnava, D. and Ruberry, W. *Government Contract Guidebook* Second Edition. Washington, DC: Federal Publications (1994); Hearn, E. *Federal Acquisition and Contract Management*. Los Altos, CA: Hearn Associates (1996); Nissen, M. *Knowledge-Based Organizational Process Redesign: Using Process Flow Measures to Transform Procurement*. Doctoral dissertation, University of Southern California School of Business Administration (1996); and Nissen, M. "Reengineering the RFP Process through Knowledge-Based Systems," *Acquisition Review Quarterly* (Winter 1997).

¹ For a relatively comprehensive description of the procurement process, the reader can consult the *Contract Specialist Workbook* (see <http://www.gsa.gov/staff/v/fai/workbooks/directions2.htm>).

¹ For example, Change Through Ex-Change Innovations - Alpha Contracting (March 1997), pp. 65-78; Drewes, R. *Early CAS Teaming for Acquisition Success*. Defense Logistics Agency Guidebook, DCMC, Ft. Belvoir, VA (1996); personal interviews with the following: PMA-201- CAPT Bert Johnston, CAPT John Scheffler, LCDR Randy Mahr, Ms. Pat Hansley; NAWCWD - Dr. Lloyd Smith, Mr. Tom Lamb, Ms. Leanna Clauch; Eglin AFB - LTC Steve Whitten, Ms. Annette Seda, Mr. Lane Clark; OC, Inc. - Ms. Cheryl Francis; many other short interviews, interactions and opportunities for direct observation with government personnel and contractor employees alike (July-September 1997); Meyer, T. "Alpha Contracting: Applying the IPT Approach to Contract Negotiations," *Army RD&A* (Jan-Feb 1997); and telephone interview with Ms. Connie Tucker, TACOM Contracts (August 1997).

¹ The experienced reader will note that joint government-contractor work can even begin *prior to* SOW development—for example, through the kinds of RFIs and presolicitation conferences conducted in the early phases of AIWS planning and development.

¹ The employment of contemporary collaborative technologies (e.g., shared Internet whiteboards, video teleconferencing, etc.) would appear to offer promise to reduce the cost and difficulties associated with work distributed across geographically-dispersed sites. This is the essence of the virtual organization, or in DoD parlance, the *virtual IPT*.

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